

EXHIBIT G

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8 UNITED STATES DISTRICT COURT
9 NORTHERN DISTRICT OF CALIFORNIA
10 SAN FRANCISCO DIVISION

11 IN RE SEAGATE TECHNOLOGY LLC
12 LITIGATION

Case No. 3:16-CV-00523

13 DECLARATION OF ANDREW
14 HOSPODOR IN SUPPORT OF
15 PLAINTIFFS' MOTION FOR CLASS
16 CERTIFICATION

17 DATE: Feb. 9, 2018
18 TIME: 9:30 a.m.
19 DEPT: Hon. Joseph C. Spero
20 Courtroom G, 15th Floor
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I. INTRODUCTION

1
2 1. I have been retained as an independent expert by counsel for the Plaintiffs in this
3 action against Seagate Technology LLC (“Seagate” or “Defendant”) regarding Seagate’s bare drive
4 model number ST3000DM001, which is marketed as a three terabyte (“3TB”) hard disk drive, as
5 well as internal drive retail kits and external drives that use the ST3000DM001.

6 2. I have been asked by Plaintiffs’ counsel to determine whether the ST3000DM001 had
7 a higher than advertised Annualized Failure Rate and whether it was suitable for RAID. I have also
8 been asked to opine, based upon my knowledge of hard drive industry’s best practices, on the
9 ST3000DM001’s level of reliability, as well as the design and manufacturing processes employed by
10 Seagate for the ST3000DM001, including reliability testing and quality control. I concluded that the
11 ST3000DM001 had a higher than advertised Annualized Failure Rate, was unsuitable for RAID, and
12 was unreliable by industry standards. Plaintiffs’ counsel then asked me to determine whether
13 Seagate knew, or should have known, of these issues and I concluded that Seagate was indeed aware
14 of them.

15 3. In preparing this report and setting forth my opinions and conclusions, I have
16 employed methods and analyses of a type reasonably relied upon by experts in my field in forming
17 opinions or inferences on the subject. To make these determinations, I have relied on my experience
18 and expertise as a Ph.D. computer engineer-scientist, my visual inspection of a ST3000DM001 drive,
19 and my review of certain documents and discovery produced in this case. Materials that I have relied
20 on in forming my opinions are listed in Appendix 1, and my curriculum vitae is attached as
21 Appendix 2.

II. QUALIFICATIONS

22
23 4. I received a Bachelor of Science degree in Computer Engineering from Lehigh
24 University in 1981, a Master of Science degree in Computer Science from Santa Clara University in
25 1986, and a Ph.D. in Computer Engineering from Santa Clara University in 1994. My Ph.D.
26 emphasis was in storage architecture and systems. My dissertation was entitled: “A Study of Prefetch
27 in Caching SCSI Disk Drive Buffers.”

1 5. I have over 25 years of experience in the data storage industry. The following is an
2 overview of my relevant responsibilities during this time period:

- 3 • Firmware Engineering for disk drive and tape drive controllers, including
4 implementation of command processing, error correction, and buffer management;
- 5 • Simulation and implementation of disk buffers and caches at Quantum;
- 6 • Architecting network storage devices that included disk and tape drives;
- 7 • Simulation and implementation of disk interfaces, including SCSI-2 and SCSI;
8 and
- 9 • Interaction with Quality Assurance and Test Engineering groups responsible for
10 performance and reliability of disk and tape drives.

11 6. At Quantum Corporation, I led a team in Systems Engineering that responsible for
12 Operating Systems, Simulation and Performance. Later, I was the key engineering contact
13 responsible for integration of the Digital Linear Tape (DLT) tape drive and library products
14 following the acquisition of Digital Equipment Corporation's storage business by Quantum.

15 7. At Western Digital Corporation, I was the Vice President of Systems Architecture
16 responsible for development of novel new storage architectures.

17 8. I have taught graduate and undergraduate courses at Santa Clara University. After
18 receiving my Master's degree in 1986, I joined the Institute for Information Storage Technology as
19 an Adjunct Lecturer, then later as a Research Fellow. I have taught courses in Computer
20 Architecture, Storage Architecture, Hard Disk and Floppy Disk Controller Design, and Grid
21 Computing. I was previously the Executive Director of the Storage Systems Research Center at
22 University of California, Santa Cruz, until May 31, 2017.

23 9. I am a named inventor on twelve United States Patents related to data storage. I have
24 also authored numerous publications in reference journals, and industry periodicals, and am often
25 cited by my peers in textbooks and journal publications.

26 10. A list of my patents and additional publications I have authored are included in my
27 curriculum vitae attached as Appendix 2 to this report.

11. I have previously testified as an expert witness in a variety of cases. A list of cases, in which I have testified, either at trial or by deposition can be found in my curriculum vitae attached as Appendix 2 to this report.

12. I have presented to the American National Standards Institute (ANSI) committee on the Small Computer Systems Interface (SCSI), the National Association of Broadcasters (NAB), the SCSI Forum, the Institute of Electrical and Electronic Engineers (IEEE) Systems Design and Network Conference, and many other storage-related conferences.

13. A more complete recitation of my qualifications can be found in my curriculum vitae attached as Appendix 2 to this report.

14. I am employed by Berg Software Design. Berg Software Design bills plaintiffs for my time at the rate of \$550 per hour for my expert witness work, plus reimbursement for reasonable travel and other out-of-pocket expenses incurred during my work on this matter. These are standard and customary rates for work of this nature. Berg Software Design and I are each compensated regardless of the facts I know or discover and/or the conclusions or opinions I reach. I have no personal or financial stake or interest in the outcome of this matter.

15. My work as an expert in this litigation is subject to an agreed protective order to which I am a signatory. This report refers to and may contain excerpts from documents that are covered by this protective order. As such, it is designated as "HIGHLY CONFIDENTIAL ATTORNEY'S EYES ONLY."

III. SUMMARY OF OPINIONS

16. In this case, I expect to testify about background issues necessary to understand the technology at issue, including an explanation of how hard disk drives ("HDD") work. Such testimony may include the historical evolution of HDD technology and the state of the industry from 2010 until the present day. I also expect to testify as to industry practices for the design and manufacturing process of hard drives, the design and manufacturing process employed by Seagate for the ST3000DM001, the accuracy of Seagate's representations regarding the ST3000DM001, and the ST3000DM001's stability, reliability, annualized failure rate, and suitability for RAID. My

1 opinions are based on my analyses and review of the documents and materials listed in Appendix 1,
 2 my visual inspection of a ST3000DM001 drive, and my education and experience. My opinions
 3 apply to the ST3000DM001 and the derivative products that incorporate the ST3000DM001,
 4 including: Desktop HDD Internal Kit, Desktop External Drive, Barracuda, BackUp Plus Mac,
 5 BackUp Plus Desk, FreeAgent GoFlex Desk, GoFlex Desk for Mac, FreeAgent GoFlex Home,
 6 Expansion Desk, Expansion Desk Plus, Business 1 BAY NAS, Business 2 BAY NAS, and Business
 7 4 BAY NAS.¹

8
 9 ¹ I understand that plaintiffs are proposing a nationwide class of the following consumers:

10 All individuals in the United States who purchased new, not for resale,
 11 on or before February 1, 2016, at least one Seagate model
 12 ST3000DM001 hard drive or at least one drive with any of the
 13 following model numbers on the box it was sold in or on the hard
 14 drive's casing or chassis: STAC3000100, STAC3000102,
 15 STAC3000202, STAC3000402, STAC3000403, STAC3000404,
 16 STAC3000602, STAM3000100, STAM3000400, STAY3000100,
 17 STAY3000102, STBC3000101, STBC3000102, STBD3000100,
 18 STBM3000100, STBN6000100, STBP12000100, STBV3000100,
 19 STBV3000200, STCA3000101, STCA3000600, STCA3000601,
 20 STCA3000602, STCB3000100, STCB3000101, STCB3000201,
 21 STCB3000400, STCB3000401, STCB3000900, STCB3000901,
 22 STCP3000100, STCP3000400, STDT3000100, STDT3000400,
 23 STDT3000402, STDT3000600, STDU3000101, STDU3000400,
 24 STEB3000100, STEB3000200, STEB3000400, STEG3000100,
 25 STEG3000400, STFM3000100, or STFM3000400.

26 I understand that in the alternative, plaintiffs are proposing the following more narrow class:

27 All individuals in the jurisdictions of California, Florida,
 28 Massachusetts, New York, South Carolina, South Dakota, Tennessee,
 and Texas, who purchased, not for resale, on or before February 1,
 2016, at least one Seagate model ST3000DM001 hard drive or at least
 one drive with any of the following model numbers on the box it was
 sold in or on the hard drive's casing or chassis:

STAC3000100, STAC3000102, STAC3000202, STAC3000402,
 STAC3000403, STAC3000404, STAC3000602, STAM3000100,
 STAM3000400, STAY3000100, STAY3000102, STBC3000101,
 STBC3000102, STBD3000100, STBM3000100, STBN6000100,
 STBP12000100, STBV3000100, STBV3000200, STCA3000101,
 STCA3000600, STCA3000601, STCA3000602, STCB3000100,
 STCB3000101, STCB3000201, STCB3000400, STCB3000401,
 STCB3000900, STCB3000901, STCP3000100, STCP3000400,
 STDT3000100, STDT3000400, STDT3000402, STDT3000600,
 STDU3000101, STDU3000400, STEB3000100, STEB3000200,

17. As set forth herein, it is my opinion that the ST3000DM001 had a higher than advertised Annualized Failure Rate, was unsuitable for RAID, and was unreliable by industry standards. I also conclude that Seagate knew of these issues. In particular, it is my professional opinion that:

- i. The reliability testing and quality control process employed by Seagate for the ST3000DM001 were flawed.
- ii. Seagate advertised and continued to advertise the ST3000DM001 as reliable and having a specific Annualized Failure Rate (“AFR”) even though its own test data did not support this position.
- iii. The ST3000DM001 was released for production before the design and manufacturing processes were stable and reliable which resulted in an abnormal failure rate.
- iv. Seagate knew that the ST3000DM001 was unstable, unreliable, and had a higher AFR than advertised.
- v. Seagate advertised and continued to advertise the ST3000DM001 as being suitable for RAID despite the fact that it knew the drive was inherently unreliable and not suitable for RAID.

IV. SUPPORT FOR AND BASES OF OPINIONS

A. Overview of Storage Technology

18. Hard disk drives are electromechanical storage devices that have been used in personal computers since the mid-1980s. Hard drives have only a few basic parts, consisting of, among other things, one or more platters, read-write heads, read-write arms, a central spindle, a spindle motor, and a controller board.

19. A platter is a circular disk on which data is stored magnetically in binary form (a code comprised of a series of zeros and ones corresponding to flux transitions on the disk). Hard drives often have more than one platter, which are stacked on top of each other a few millimeters apart. The ST3000DM001 has three platters with a capacity of 1TB each (one terabyte equals 1000 gigabytes or one million megabytes).

STEB3000400, STEG3000100, STEG3000400, STFM3000100, or STFM3000400.

20. The central spindle is the shaft that holds the platters in place and allows them to rotate at high speeds. The central spindle is powered by a spindle motor.

21. The read-write arm, which has a tiny read-write head on the end, stretches out over the platter and moves over it, reading and writing data to the platter while the platter is spinning. Since both sides of a platter are usually used for data storage, there are typically two read-write heads for each platter. The ST3000DM001 was first produced using six heads, with data on each of the three platters accessed by a pair of heads located above and below each platter.

22. The controller board controls components that allow the hard drive to function. Put simply, the controller board controls the flow of data to and from the platters in the hard drive.

B. The ST3000DM001 Hard Disk Drive²

23. The drives at issue in this litigation contain the ST3000DM001 hard disk drive. The ST3000DM001 had an advertised capacity of 3 Terabytes (“3TB”) and had been in production since 2011. The ST3000DM001 consisted of the following products:

Marketing Product Name	Bare Drive Model Number ³
Desktop HDD Internal Kit	ST3000DM001
Desktop External Drive	ST3000DM001
Barracuda	ST3000DM001
BackUp Plus Mac	ST3000DM001
BackUp Plus Desk	ST3000DM001
FreeAgent GoFlex Desk	ST3000DM001
GoFlex Desk for Mac	ST3000DM001
FreeAgent GoFlex Home	ST3000DM001
Expansion Desk	ST3000DM001
Expansion Desk Plus	ST3000DM001
Business 1 BAY NAS	ST3000DM001
Business 2 BAY NAS	ST3000DM001

²

³ The Desktop HDD Internal Kit and the Barracuda were internal drives. The Desktop External Drive, BackUp Plus Mac, BackUp Plus Desk, FreeAgent GoFlex Desk, GoFlex Desk for Mac, FreeAgent GoFlex Home, Expansion Desk, and Expansion Desk Plus were external drives. Although the external drives had different model numbers on their boxes and outer casings, the drives inside of the casings were model number ST3000DM001. Likewise, the Desktop HDD Internal Kit had a different model number on its box, but it was a ST3000DM001 drive. The Business 1, 2, and 4 Bay NAS were network attached storage devices that came with ST3000DM001 drives.

Marketing Product Name	Bare Drive Model Number ³
Business 4 BAY NAS	ST3000DM001

See Seagate Technology, LLC's Second Amended Response to Interrogatory No. 9, at p.3.

24. These products were all based on and included the same, highly leveraged, internal design. This design was referred to within Seagate as the "Grenada" family of disk drives.

25. Because demand for the product was high, Seagate planned to release the Grenada in phases and highly leverage its use. Internally, the phased Grenada iterations were referred to as the Grenada Classic, Grenada BP,⁴ Grenada BP PL,⁵ and Grenada BP 2,⁶ and they were all model number ST3000DM001. In this report, "Drive" will refer to a disk drive in the Grenada family having model number ST3000DM001, including external drives and internal retail kits that have a different model number on their boxes and/or outer casings but have a ST3000DM001 inside.

26. Seagate used the following internal product code names for the Grenada drives:

Product Code Name	Marketing Product Name
Retail Kit	Desktop HDD Internal Kit
Raptor	Desktop External Drive
Grenada	Barracuda
Grenada BP	Barracuda
Grenada BP PL	Barracuda
Grenada BP 2	Barracuda
Stratus	BackUp Plus Mac
Stratus	BackUp Plus Desk
Udon	BackUp Plus Mac
Udon	BackUp Plus Desk
Rockit Desk	FreeAgent GoFlex Desk
Rockit Desk	GoFlex Desk for Mac
Explorer	FreeAgent GoFlex Home
Falcon Desk	Expansion Desk
Sake	Expansion Desk Plus
Sentinel	Business 1 BAY NAS

⁴ Oft times referred to in Seagate documentation as "GrenadaBP" or by its full name "Grenada BlockPoint."

⁵ Oft times referred to in Seagate documentation as "GrenadaBPPL," "GrenadaBP+," or by its full name "Grenada BlockPoint Plus."

⁶ Oft times referred to in Seagate documentation as "GrenadaBP2" or by its full name "Grenada BlockPoint 2."

1 See Seagate Technology, LLC's Second Amended Response to Interrogatory No. 9, at p.3.

2 **C. Measures of Reliability: Annualized Failure Rate and Mean Time Between Failure**

3 **1. AFR and MTBF Generally**

4 27. Annualized Failure Rate, or AFR, is a measure of reliability for a device or
5 component, and it is widely used in the hard drive industry. AFR is the projected percentage of
6 drives of a particular model that will fail in a given year. Changes in AFR can expose problems with
7 a drive's manufacture or design but do not include failures due to misuse by the end-user.
8 Furthermore, AFR projections are based upon an assumption that failures are independent. This
9 assumption is not valid when drives have related failures resulting from contamination, the
10 introduction of a faulty part, or other design or manufacturing process issues. As discussed in more
11 detail below, common failure modes of the ST3000DM001 were contamination and head-related
12 failures.

13 28. Mean time between failure, or MTBF, is another measure of hard drive reliability
14 used across the hard drive industry. It refers to the average number of hours that are projected to
15 elapse between one failure and the next in a population of hard drives.

16 29. There is an inverse relationship between AFR and MTBF; the higher the AFR, the
17 lower the MTBF. Likewise, the lower the AFR, the higher the MTBF. AFR can be calculated from
18 MTBF, and vice-versa.

19 30. AFR is widely advertised by hard drive manufacturers in consumer-facing materials
20 such as product manuals and specification sheets. As discussed in more detail below, Seagate
21 advertised the ST3000DM001 as having an AFR of <1%.

22 31. MTBF was widely quoted in consumer-facing materials, but in recent years the trend
23 in the industry has been to quote AFR rather than MTBF. This is because MTBF can be confusing to
24 consumers; MTBF ratings often reach hundreds of thousands of hours or even a million hours or
25 more, and this has led some consumers to believe that their hard drives can function for 25, 50, or
26 even 100 years. This is not the case, however, because like AFR, MTBF is a population statistic and
27 it doesn't reflect the number of hours that an individual unit will last. Largely due to this potential for
28

1 confusion, the industry has shifted towards stating the AFR in consumer materials because it is easier
2 to understand.

3 32. Around the time that the ST3000DM001 was introduced, Seagate moved away from
4 quoting MTBF to instead quoting just AFR. The rationale for this was substantially the same as the
5 above.⁷ Internally, Seagate continued to use both MTBF and AFR in assessing a hard disk drive's
6 reliability.

7 33. As would be expected of any reliability metric, AFR is not accurate indefinitely.
8 Rather, AFR is a failure rate that applies over a specific interval: the expected service lifetime of the
9 product. The expected service lifetime for most hard drives is five years, so the advertised AFR of a
10 hard drive, if properly calculated, represents the annual failure rate during the first five years the
11 drive is used to store user data. The ST3000DM001 was designed with an expected service life of
12 five years,⁸ but internal Seagate testing revealed that the AFR was projected to be significantly
13 greater than 1% for even the first year of use.⁹

14 2. Calculating AFR and MTBF

15 34. The data used to calculate AFR and MTBF is usually obtained by conducting
16 accelerated life testing. Accelerated life testing consists of running a large population of drives 24
17 hours per day and 7 days per week for at least 30 days in special test chambers which subject the
18 drives to extreme conditions, such as temperature and voltage levels above and below the values

19 ⁷ Seagate, Hard disk drive reliability and MTBF / AFR http://knowledge.seagate.com/articles/en_US/FAQ/174791en?language=en_US&key=ka030000000tmWGAAY&kb=n&wwwlocale=en-us
20 (last accessed October 10, 2017).

21 ⁸ See FED_SEAG0056259, at 56262. This page contains a chart listing a 5-year service life goal
22 for various Seagate products, including desktop drives such as the ST3000DM001 (labeled in the
23 chart as "DT Disty HDD"), and external drives (labeled as "SBS Backup HDD"). Seagate
24 intentionally failed to inform consumers in many published materials that the ST3000DM001 had a
five-year service life. See FED_SEAG0055831, at 55833 ("Five year service life will not be part of
customer specs/contracts.").

25 ⁹ In fact, until 2014, Seagate only calculated the AFR for the first year of Drive use. This is
26 because Seagate presumed that the Drive's failure rate would decline after the first year. As will be
27 explained in greater detail in Section H, the Drive's failure rate actually increased with time, thus
28 Seagate underestimated the true AFR by only calculating the first-year AFR. None of the Seagate
consumer-facing materials I have reviewed informed consumers that the AFR Seagate was
advertising was only for the first year.

1 listed in the disk drive's specification. Running the drives under these extreme conditions
2 "accelerates" the testing to allow the prediction of failures over the expected lifetime of a disk drive.

3 35. The data obtained from accelerated life testing that is used to calculate AFR and
4 MTBF includes, among other things, the number of drive failures that occurred during testing, the
5 amount of time it took the drives to fail, the temperature of the test chambers, the voltages provided
6 to the drives, and the number of power-on hours the drives were designed for.

7 36. Power-on hours, abbreviated "POH," are the number of hours a year that the drive is
8 powered on. Seagate assumes a POH value of 2400 when *calculating* the AFR and MTBF for
9 desktop drives, such as the ST3000DM001. This is equivalent to approximately 6.5 hours a day, 7
10 days a week, or approximately 9 hours a day, 5 days a week, for an entire year.

11 37. As discussed more fully in Section J, below, notwithstanding that Seagate assumed an
12 average POH value of 2400 for desktop drives, including the ST3000DM001, when it calculated the
13 AFR, several iterations of the Product Manual for the ST3000DM001 represented to consumers that
14 its AFR is based upon an 8760 POH workload,¹⁰ which is equivalent to 24 hours a day, 7 days a
15 week. If a drive is designed for 2400 POHs and its AFR is calculated using that POH figure, the
16 stated AFR will not accurately reflect the actual failure rate of the drive if it is used at 8760 POHs.

17 38. In addition to the foregoing, a mathematical function known as a Weibull distribution
18 is employed when calculating AFR. Data obtained during testing is used to calculate the beta
19 parameter of the Weibull distribution, and the beta is then used in projecting AFR. As discussed in
20 more detail in Section H, the Weibull beta calculated by Seagate did not match the true failure
21 characteristics of the ST3000DM001, which demonstrates that Seagate's testing was flawed and
22 underestimated the true AFR of the Drive.

23
24
25 ¹⁰ The Product Manual for the ST3000DM001 was updated approximately a dozen times,
26 including in October 2012, March 2014, May 2014, August 2014, and January 2015. In the October
27 2012 Product Manual, the workload was quoted as 8760 POHs, and it remained so until it was
28 changed to 2400 POHs in January 2015. *See* October 2012 Product Manual, FED_SEAG0030657, at
30668; March 2014 Product Manual, FED_SEAG0004163, at 4171; May 2014 Product Manual,
FED_SEAG0003839, at 3847; August 2014 Product Manual, FED_SEAG0030777, at 30786;
January 2015 Product Manual, FED_SEAG0004438, at 4447.

D. Seagate's Drive Development and Manufacturing Process

39. Seagate follows a "Product Life Cycle Process" when it designs, develops, and releases drives. This process consists of product planning, research and technology development, and drive development stages.¹¹ In the drive development stage, there are 11 phases, ranging from "Advanced Product Development" to "EOL," which stands for "end of life" (drive discontinuation).¹² At the end of each phase is a checkpoint, many of which are referred to as "exits," which contain certain criteria and milestones that must be met before the drive can proceed to the next phase.¹³

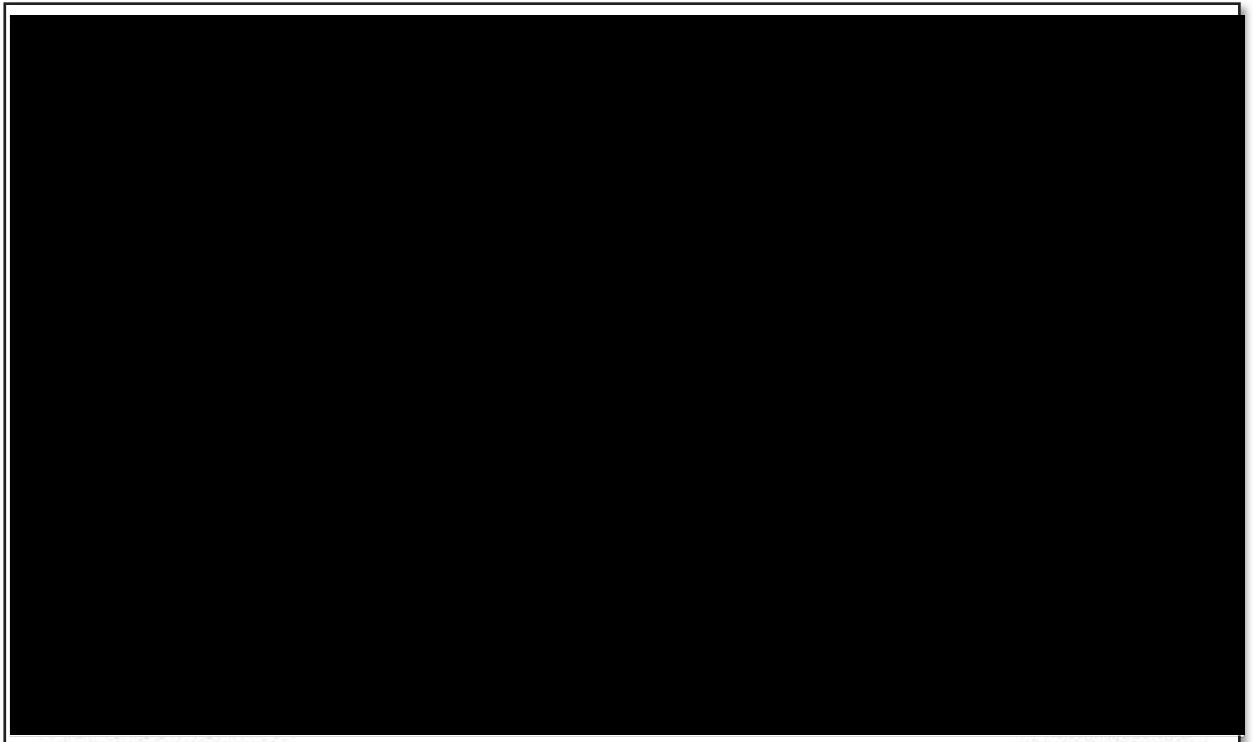


Figure 1: Seagate's Product Life Cycle Process

40. [REDACTED]

¹¹ See FED_SEAG0027285, at 27287.

¹² *Id.*

¹³ See *id.*; Almgren Dep., at 98:8-13, 100:14-101:9.

¹⁴ Almgren Dep., at 111:5-112:11.

1 [REDACTED]
2 [REDACTED]
3 [REDACTED]
4 41. [REDACTED]
5 [REDACTED] [REDACTED] The term “OEM” refers to drives that are sold to Original Equipment ,anufacturers,
6 which are companies like Apple and Hewlett-Packard that put the drives into the computers they sell
7 to consumers. The term “disty” refers to the “distribution channel,” which includes bare drives that
8 Seagate sells to resellers like NewEgg and Amazon, who in turn sell them to consumers. A bare
9 drive is simply a hard drive that is sold without any branded packaging or accessories such as cables
10 or mounting brackets.

11 42. The ST3000DM001 “SBS” drives, however, were released *before* the OEM and
12 distribution drives, [REDACTED], because the requirements Seagate imposed
13 on these drives to be released was less stringent.¹⁵ The term “SBS” stands for “Seagate Branded
14 Solutions,” and it consisted of Drives sold in Seagate-branded packaging with accessories such as
15 cables, and it included Internal Drive Kits and external Drives.¹⁶ SBS Drives were sold by Seagate to
16 retailers such as Best Buy and Costco, who resold them to consumers.

17 43. The Grenada family of drives consisted primarily of the Grenada, sometimes referred
18 to as the “Grenada Classic,” the Grenada BP, and the Grenada BP2. The Grenada Classic went
19 through the entire Product Life Cycle Process, but the Grenada BP and the Grenada BP2, which were
20 released after the Grenada Classic, did not because they were not “brand-new designs” but were
21 rather updates of the Grenada Classic.¹⁷ Consequently, the development time for these version of the

22
23 ¹⁵ See Almgren Dep. 119:3-122:14.

24 ¹⁶ See Almgren Dep. 117:9-118:1. See also FED_SEAG0028126, at row 842 (listing the 3TB
25 Desktop HDD Internal Kit as an SBS drive), row 2654 (listing the Backup Plus Mac as a SBS drive),
26 row 3295 (listing the BackUp Plus Desk as a SBS drive), row 5465 (listing the Expansion Desk as a
27 SBS drive), row 635 (listing the Expansion Desk Plus as a SBS drive), row 3676 (listing the GoFlex
28 Desk as a SBS drive).

¹⁷ See Dewey Dep. at 207:7-208:8. Patrick Dewey, a corporate designee for Seagate, testified
that, with regard to the Grenada BP2, “So rather than a brand-new design, new capacity drive, this is
deemed to be – we’re trying to demonstrate equivalency with the changes for the product. And so
that does not require you to go through the full step of the PLP life cycle test process. [REDACTED]

1 Grenada was shorter.¹⁸ As discussed above, because they were all based on the same design and part
 2 of the same drive family, Seagate used the same model number, ST3000DM001, for each iteration of
 3 the Drive.

4 **E. The Advertised Performance of the ST3000DM001**

5 44. Seagate first released the ST3000DM001 on or around April 28, 2011. The Drives
 6 released at this time were the SBS drives – external drives and the internal drive kit. Seagate released
 7 the “bare drive” ST3000DM001 on or around October 18, 2011.

8 45. From the time the ST3000DM001 was first released in 2011, Seagate advertised its
 9 AFR as <1%, 0.34%, or both. Seagate also marketed the Drive as “best-fit” and “perfect” for desktop
 10 RAID.¹⁹

11 46. I reviewed numerous documents that were produced by Seagate during discovery
 12 containing statements about the Drive’s AFR and RAID capabilities. I also reviewed multiple
 13 archived versions of Seagate’s website dating back to November 2011 by using the “Wayback
 14 Machine.” The Wayback Machine is a webpage archival service run by the Internet Archive, a non-
 15 profit organization based in San Francisco. The Wayback Machine has been saving and archiving
 16 webpages across the Internet since 1996, and to date it has archived over 306 billion webpages.²⁰

17 47. The Wayback Machine automatically visits a webpage periodically (every few weeks
 18 or months) and captures a new version of the page. Each time a new version of the webpage is
 19 captured, it is archived and becomes accessible to anyone who searches for the webpage on the
 20 Wayback Machine website, <https://archive.org/web/>. Therefore, entering “Seagate.com” into the
 21 Wayback Machine website allows the user to view the Seagate website as it appeared on any of the
 22 numerous dates on which it was archived.

23
 24
 25
 26 ¹⁸ See Almgren Dep, at 38:3-12.

27 ¹⁹ FED_SEAG0015567, at 15568.

28 ²⁰ See Wayback Machine, <https://archive.org/web/> (last accessed October 31, 2017) (stating
 “Explore more than 306 billion web pages saved over time.”).

48. Around the time that Seagate first released the ST3000DM001 in April 2011, it released a Product Manual for the Drive. The Product Manual contained information and specifications for the Drive, such as its capacity, maximum operating temperature, and AFR, as well as instructions on how to install the drive. It was available as a PDF document that could be downloaded from Seagate's website.

49. The Product Manual stated that the ST3000DM001 had an AFR of 0.34%, as shown below.²¹

Non-recoverable read errors	1 per 10 ¹⁴ bits read	1 per 10 ¹⁴ bits read
Annualized Failure Rate (AFR)	0.34%	0.34%
Warranty	To determine the warranty for a specific drive, use a web browser to access the following web page: support.seagate.com/customer/warranty_validation.asp . From this page, click on the "Verify Your Warranty" link. You will be asked to provide the drive serial number, model number (or part number) and country of purchase. The system will display the warranty information for your drive.	
Load/Unload cycles (25°C, 50% rel. humidity)	300,000	300,000
Supports Hotplug operation per the Serial ATA Revision 2.5 specification	Yes	Yes

*One GB equals one billion bytes when referring to hard drive capacity. Accessible capacity may vary depending on operating environment and formatting.

**During periods of drive idle, some offline activity may occur according to the S.M.A.R.T. specification, which may increase acoustic and power to operational levels.

Figure 2: Excerpt from April 2011 Product Manual (highlight added for ease of reading).

50. Seagate also advertised the AFR of the ST3000DM001 directly on its website. By November 2011, at the latest, Seagate's website listed the AFR as <1%, as shown in the figure below.

²¹ See April 2011 Product Manual FED_SEAG0019045, at FED_SEAG0019056.

SPECIFICATIONS	
Model Number	ST3000DM001
Interface	SATA 6Gb/s
Cache	64MB
Capacity	3TB
Areal density (avg)	625Gb/in ²
Guaranteed Sectors	5,860,533,168
PHYSICAL	
Height	26.1mm (1.028 in)
Width	101.6mm (4.0 in)
Length	146.99mm (5.787 in)
Weight (typical)	626g (1.38 lb)
PERFORMANCE	
Spin Speed (RPM)	7200 RPM
Average latency	4.16ms
Random read seek time	<8.5ms
Random write seek time	<9.5ms
RELIABILITY	
Annual Failure Rate	<1%
POWER	
Maximum start current, DC	2.0

Figure 3: Relevant portion of archived page from Seagate's website as it appeared on November 29, 2011 (highlight added).²²

51. By November 2011 at the latest, Seagate released a Data Sheet for the ST3000DM001, which was available as a PDF document that could be downloaded from Seagate's website.²³ Like the Product Manual, the Data Sheet contained specifications for the Drive, including AFR, but also contained marketing statements about the Drive's "Key Advantages" and "Best-Fit Applications."

52. The Data Sheet advertised the AFR of the ST3000DM001 as <1%, and it asserted that "Desktop RAID" was one of the "Best-Fit Applications" for the Drive.²⁴ Other consumer-facing

²² Seagate, *Barracuda Desktop Hard Drives*, https://web.archive.org/web/20111129033926/http://www.seagate.com:80/www/en-us/products/desktops/barracuda_hard_drives#TabContentSpecifications (click on "Specifications" tab) (archived November 29, 2011).

²³ Seagate, *Barracuda Desktop Hard Drives*, https://web.archive.org/web/20111129033926/http://www.seagate.com:80/www/en-us/products/desktops/barracuda_hard_drives (archived Nov. 29, 2011) (containing a link to the Data Sheet).

²⁴ FED_SEAG0015567, at 15568.

materials subsequently published by Seagate advertised the Drive as “perfect” for “desktop RAID arrays.”²⁵

53. By April 2012, Seagate changed the Drive’s AFR listed on Seagate’s website from <1% to “0.34%, <1%,” as shown below. The Data Sheet remained unchanged.

PRODUCT NAME	AREAL DENSITY	ENCRYPTION	AFR	MEAN TIME BETWEEN FAILURES	AVERAGE OPERATING POWER
Baracuda LEARN MORE Baracuda Data Sheet (PDF)	328 Gbit/15GBin ² 328Gbit/15GBin ² 625 Gbit/15GBin ² 625Gbit/15GBin ²	Security/Encryption, Volume level encryption	0.34%, <1%	750,000hr	5.90W, 6.10W, 6.7W, 8.0W

Figure 4: Relevant portion of an archived page from Seagate’s website as it appeared on April 28, 2012.²⁶

54. Seagate continued to advertise the AFR of the ST3000DM001 on its website as “0.34%, <1%” until at least January 2013.²⁷ The AFR specification was thereafter removed from the

²⁵ For instance, multiple iterations of the Desktop HDD Kit Data Sheet stated that the Drive is “perfect for” RAID. See FED_SEAG0000476 (copyrighted 2015); FED_SEAG0020175 (copyrighted 2014); FED_SEAG0002109 (copyrighted 2013). Moreover, Seagate supplied product descriptions to retailers such as Amazon, Newegg, and Walmart, and the retailers published the descriptions on webpages where they sold the ST3000DM001. These descriptions stated that the ST3000DM001 was “perfect when you need to . . . implement a desktop RAID.” FED_SEAG55589, at 55592.

²⁶ See Seagate, *Desktop Hard Drives*, <https://web.archive.org/web/20120428124406/http://www.seagate.com:80/internal-hard-drives/desktop-hard-drives/> (click on “specifications” tab) (archived April 28, 2012).

²⁷ See Seagate, *Desktop Hard Drives*, <https://web.archive.org/web/20130117005718/http://www.seagate.com/internal-hard-drives/desktop-hard-drives/> (click on “Specifications” tab) (archived Jan. 17, 2013). In or around February 2013, Seagate changed the marketing name of the ST3000DM001 (the name that appears on the box, on the Drive itself, and on consumer-facing

1 website for a brief period, only to return in September 2013 as “0.34%.”²⁸ The AFR specification
 2 remained on the website until at least January 2014.²⁹

3 55. Since that time, the Data Sheet advertising the AFR as <1% was, and still is, hosted
 4 on the Seagate website. Indeed, as of November 2, 2017, performing a Google search for the phrase
 5 “ST3000DM001 Data Sheet” returns said Data Sheet as the first result.

6 56. Moreover, the AFR specification for the ST3000DM001 remained in various other
 7 consumer-facing materials. Namely, an AFR of <1% was also quoted in the Drive’s Product Manual
 8 from the January 2015 revision until at least the September 2016 revision.³⁰ This same AFR figure
 9 was also quoted in various product catalogues published by Seagate.³¹

10 57. In addition to statements about the specific AFR and RAID capabilities, the Data
 11 Sheets and Seagate’s website Seagate advertised the ST3000DM001 as a reliable product.³²

12 58. Although Seagate continued to advertise that the Drive was reliable and had an AFR
 13 of <1%, it was aware that there were serious problems with the Drive which affected its reliability
 14 and that its own internal testing revealed that the Drive’s AFR was higher than advertised.

15
 16 materials) from Barracuda to Desktop HDD. Despite the marketing name change, the Drive was still
 17 a ST3000DM001 and was listed as such in consumer-facing materials and on the label affixed to the
 Drive.

18 ²⁸ See Seagate, *Desktop Hard Drives*, [https://web.archive.org/web/20130911084603/http://](https://web.archive.org/web/20130911084603/http://www.seagate.com:80/internal-hard-drives/desktop-hard-drives/)
 19 [www.seagate.com:80/internal-hard-drives/desktop-hard-drives/](https://web.archive.org/web/20130911084603/http://www.seagate.com:80/internal-hard-drives/desktop-hard-drives/) (click on “Specifications” tab)
 (archived September 11, 2013).

20 ²⁹ See Seagate, *Desktop Hard Drives*, [https://web.archive.org/web/20140124073650/http://](https://web.archive.org/web/20140124073650/http://www.seagate.com/internal-hard-drives/desktop-hard-drives/)
 21 [www.seagate.com/internal-hard-drives/desktop-hard-drives/](https://web.archive.org/web/20140124073650/http://www.seagate.com/internal-hard-drives/desktop-hard-drives/) (click on “Specifications” tab) (archived
 Jan. 24, 2014).

22 ³⁰ See, e.g. FED_SEAG0004438, at 4447 (Jan. 2015 Product Manual); FED_SEAG0030293, at
 23 30302 (Sept. 2016 Product Manual). It is my understanding that the September 2016 Product Manual
 was the most recent manual produced by Seagate during discovery in this litigation and is therefore
 presumably the most recent iteration that has been released by Seagate.

24 ³¹ See July 2012 Storage Solutions Guide, at p.17, available at [https://www.seagate.com/files/](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solutions-guide-sg1351-11-1210us.pdf)
 25 [www-content/product-content/_cross-product/en-us/docs/storage-solutions-guide-sg1351-11-](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solutions-guide-sg1351-11-1210us.pdf)
 26 [1210us.pdf](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solutions-guide-sg1351-11-1210us.pdf); October 2012 Storage Solutions Guide, FED_SEAG31474, at 31492; October 2013
 Storage Solutions Guide, at p. 31, available at [https://www.seagate.com/files/www-content/product-](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-1310us.pdf)
 27 [content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-1310us.pdf](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-1310us.pdf).

28 ³² For example, the Data Sheets stated, “Seagate AcuTrac servo technologies delivers dependable
 performance, even with hard drive track widths of only 75 nanometers.”

F. When Seagate First Shipped the ST3000DM001 to Customers, It Knew the Drive's AFR Was Higher than Advertised

59. As set forth above, when Seagate first shipped the ST3000DM001, it advertised to customers that the Drive had an AFR of 0.34%, and it also advertised an AFR of <1% on its website and in marketing materials. Seagate subsequently advertised the AFR as "0.34%, <1%" or <1% on its website and in various consumer literature.

60. However, a review of Seagate's internal testing documents reveals that the Drive was approved for shipment despite having an AFR that exceeded the specification advertised, and it remained in excess of that specification. Accordingly, Seagate knew that it was falsely advertising the failure rate of the Drive.

61. The first iteration of the Drive was approved for shipment on April 28, 2011. As per Seagate's "Product Life Cycle Process" described above, for a Drive to be approved for shipment for sale to customers, a core development team must prepare and submit for approval a Shipping Approval Document ("SAD"). The first SAD document for the Drive was produced as FED_SEAG0026697-26750, and is titled "Grenada SBS SAD Final 4/28/11." Expanding the acronyms in the title leads to "Grenada Seagate Branded Solutions Shipping Approval Document Final 4/28/11".

62. Thus, this is the document that was submitted for approval to start shipping the first iteration of the Drive in April 2011. It was approved. The summary page of the SAD is reproduced below.

SBS Ship Approval						
Product Name: Grenada			Approval Date: 4/27/2011			
Design Center: LCO			Goal: Commence SBS Shipments			
Volume Factory: Korat			Configuration: 1TB, 2TB, 3TB			
	CRITERIA		EXCEPTIONS/ STATUS			MET?
1a	Integration DPPM Goal Achieved <i>Demo ≤ 8,000 dppm</i>	DEMO ≤ 8k DPPM	RAW	DEMO 6.8K	PROJ. N/A	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
1b	168-Hr DPPM Goal Achieved <i>Demo ≤ dppm</i>	DEMO N/A DPPM	RAW	DEMO	PROJ.	N/A
2	MTBF Goal Achieved <i>Demo ≥ 100k hrs</i> SBS Mini RDT completed/fit for use	DEMO ≥ 100k Hrs	RAW	DEMO 101K	PROJ. 167K	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
3	Gen 2/3 Product Assurance and Factory Testing Complete - SBS DMT testing and Reliability subset of drive DMT testing	In progress of Regressing 1D packaging test with proper packaging, low risk				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
4	Firmware/Compatibility Testing Complete - SBS firmware and compatibility completed/fit for use and All High Risk items fix validated.					<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
5	Factory Prime Yields meet Phase 0 goals	Product Yields 1D: 76.8n, 2D: 67.8c, 73.2n 3D: 56.6n				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
6	Process Readiness Audit and Process Verification Test Results approved by Volume Factory and Design Center. - Includes QA Hardware/Software Readiness and SBS approval					<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
7	Component sources defined on the SSP approved to ASL level AE/AB. Exceptions have defined/underpinned closure plans. Qualified Sources can support Master Schedule Requirements.	1.				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
8	Product Stewardship Declaration of Compliance has been issued per Corporate Product Stewardship Certification Process.	1.				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
9	Inventory / Material Disposition - Complete roll-up of all Factory and DC pre-SAD config inventory/WIP/FG and Disposition.	1				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
10	All other exceptions to the CTU Ship Approval Document have been closed.	Korean Certification. Not a gate for SBS.				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
11	Complexity Health Index - Does not deviate from Phase 0 Contract	A. CH Index Score - 296 B. CC Budget - 80				<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO

Figure 5: Status of Grenada at time of shipping approval (FED_SEAG0026699)

63. This summary page is significant for a variety of reasons. First, it shows that to be approved for shipment to customers, the Drive had to have an MTBF of greater or equal to 100K hours. The summary page concludes that the demonstrated MTBF at the time was 101K hours – a mere 1% over target.

64. However, an MTBF of 100K hours for a hard drive tested with a 2400 POH assumption is equivalent to an AFR of 2.37%. Hence, Seagate's projected AFR requirement upon releasing the Drives was significantly higher than the AFR of 0.34% that Seagate advertised. Likewise, notwithstanding that Seagate considered the MTBF goal to be achieved, the Drive was released with a projected MTBF of 101K hours, which is equivalent to an AFR of 2.35%. This is **7 times greater** than the 0.34% AFR that Seagate was advertising to consumers at the time.

65. As will be discussed in more detail below, the Drive also had an AFR (a projected first year Weibull) of 7.006%. This is **20 times greater** than the 0.34% AFR that Seagate was

advertising to consumers at the time. Testing identified problems that, when corrected, would lead to an AFR of 2.35%, which is **7 times greater** than Seagate's advertised 0.34% AFR.

66. Row 2 in the above graphic also shows a value titled "PROJ" which represents the MTBF that would presumably be achievable by Seagate once all identified corrective actions had been applied. The aspirational projection of 167,000 hours is significantly better than the demonstrated 101,000 hours; however, the projection would nevertheless result in an AFR of 1.43%, or **4 times greater** than the AFR that Seagate was advertising at the time.

67. Another important part of this Shipping Approval Document is the "Reliability Summary." The top part of the page is reproduced below.

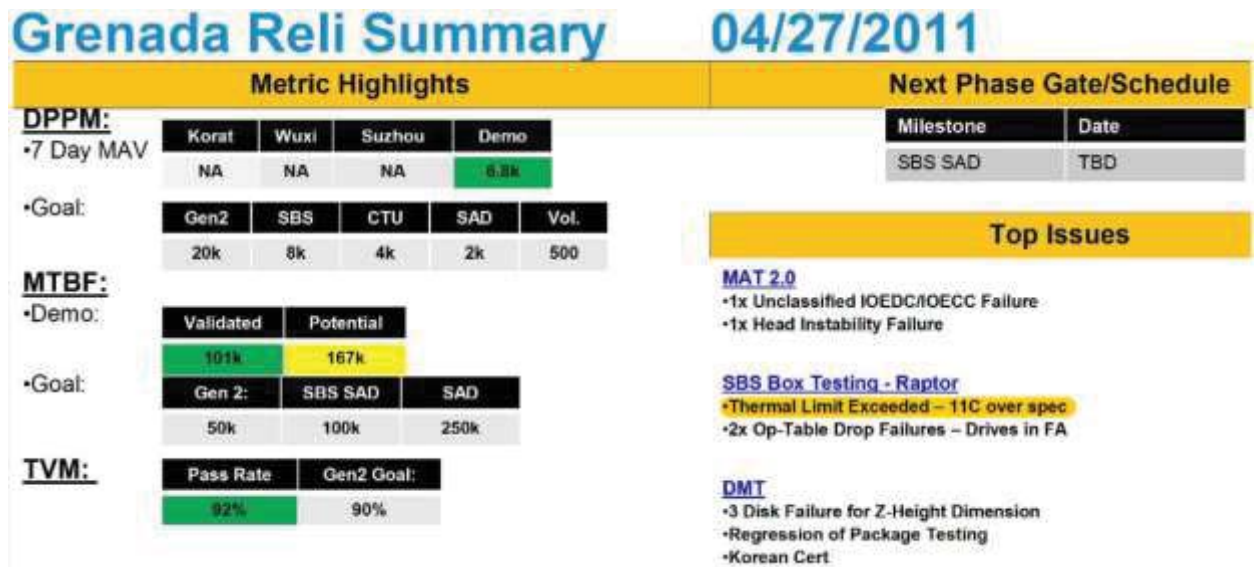


Figure 6: Grenada Reliability Summary Showing a Large Over-Temperature Problem (FED_SEAG0026697, at 26703) (highlight added)

68. Notably, this page indicates that, when the case temperature for the Desktop External Drive³³ was tested, the Drive was 11°C above the temperature limit. It is well known that the reliability of almost all products is a strong function of temperature. Indeed, this is what Seagate has to say on the topic:

³³ As set forth in Seagate's Second Amended Interrogatory Answers, at p.3, the term "Raptor" is a reference to the product marketed as the "Desktop External Drive."

69. The SAD indicates that the Desktop External Drive was not approved for release at the time of the SAD document due to temperature and drop test failures.³⁵

71. The next page was also illuminating and is partially reproduced below:

*Figure 7: Grenada Maturity Acceptance Testing Combined Fix Effectiveness Table.
Top part of FED_SEAG0026704*

73. The “MAT 1.2/1.3/BtC/2.0” language indicates that the Drive underwent multiple of testing. If the results of a test did not meet Seagate’s maturity acceptance criteria, Seagate repeat it and assign a different MAT number (or other designator) to it. Thus, at the time of D document, Seagate had to repeat the testing of the ST3000DM001 at least four times, with tests likely preceding “MAT 1.2” (it would be unusual to designate the first test as “1.2”

³⁵ See FED SEAG0026697, at 26717.

rather than “1.0”). The storage industry uses first pass yield as a measure of manufacturing process efficiency and maturity. Any drive that requires repeat testing, sometimes due to reworking or replacing defective components, increases the cost of goods sold. For this reason, it is highly unusual to retest drives more than once. Testing a drive four times, with different tests, is likely an attempt to whittle down a “bone pile” of drives that failed one or more previous tests and must be moved from “work in process” into either the distribution channel or scrap, effectively taking them out of inventory and off the books.

74. The table in Figure 8 below lists, among other things, the most common failures (under the “issues” column), the proposed corrective action, the demonstrated and potential fix effectiveness (under the “Eff. Factors” column), and then a computation of the impact that the proposed corrective action will have on the AFR based on the demonstrated and potential fix effectiveness (under the “Reduced AFR” column).

75. This table evidences that, based on the results of its reliability tests on 1651 units with an assumed POH of 2400 hours and a Weibull Beta of 0.608098, Seagate concluded that the Drive had a projected AFR of 7.006%. Seagate further projected an AFR of 2.34% once corrective actions were in place to address the identified defects with the Drives. Even with the corrective actions taken by Seagate, the projected AFR remained well in excess of 1%.

76. The rest of the page, and the following page, list a plethora of issues, the corrective action, and the validation of the fix. Seagate assigned a “fix effectiveness” to each proposed corrective action (i.e., that the corrective action would work X% of the time) to come up with a Mean Time Between Failures of 101k and a “demonstrated reduced AFR” of 2.34%. These numbers are shown in the figure below, which is the lower part of chart.

SPPL 402 Bad PES in Quarter Track Position & VCAT Peak	OCUM changed to T09 Change servo level set to map out areas of defects Target code release v4	Validating PFI 402 with test code EPOF in Korea	1	0.004%	0%	90%	7.006%	0.950%	PFI 402/404
SPPL 403 Mismatch Defect - MAT 2.0	Implement full DMR in CFS. Implementation date v44		1	0.004%	0%	90%	7.006%	0.950%	PFI 403/404
SPPL 479 Failure to Spin Error	Issue not repeatable in PFI or SE. Pending fix		1	0.004%	0%	90%	7.006%	7.006%	PFI 403/479
SPPL 479 Head Instability - MAT 2.0	DETCH ON in Runtime. Implementation in PCD 3.0		1	0.004%	0%	90%	7.006%	7.006%	PFI 403/479
SPPL 472 Offtrack Write due to insufficient ZEST correction near system area	Remove ZEST Taper near the system track. Write TAPER_ZEST_NEAR_RESERVED_ZONE (11A) ENABLE_ZEST_DATA_OVERLAY) = (11A) ENABLE_ZEST_DATA_OVERLAY) Write TAPER_ZEST_NEAR_TRACK (11A) ENABLE_ZEST_DATA_OVERLAY) = (11A) ENABLE_ZEST_DATA_OVERLAY) Release Servo Code 4		1	0.004%	0%	90%	7.006%	0.950%	PFI 403/472
Single Bit Mismatch	NANVAODR PART DQ4		1	0.004%	0%	90%	7.006%	0.950%	PFI 403/472
Write Write			1	0.004%	0%	90%	7.006%	7.006%	PFI 403/472
Total Number of Fails			429	Reduced AFR		2.34%	1.42%		
				Corresponding MTBF		101K	167K		

Figure 8: Lower part of chart showing MTBF of 101K / 167K hours and a corresponding AFR of 2.34% / 1.43% (FED_SEAG0026705).

77. Because the above table was contained in the SAD document for the ST3000DM001, which authorized the Drive for release and shipment, it shows that the Drive was released with an AFR of 2.34%, which is approximately **6.9 times greater** than the advertised AFR of 0.34%, and approximately **2.4 times greater** than an AFR of <1%.

78. The second item in the “Reduced AFR” row, 1.43%, is the “potential reduced AFR.” This was a projection of the lowest possible AFR that could be achieved based on the potential effectiveness, rather than the demonstrated effectiveness, of the corrective actions. In other words, it is an aspirational projection. Thus, Seagate projected that it could not possibly meet the advertised AFR of 0.34%, or even an AFR of <1%, with the fixes it devised. But, Seagate released the Drives anyway.

79. One of the failures that is listed on the above chart is “head instability,” which accounted for 23 failures out of 129 total failures and was the most prevalent failure type. The magnetic recording heads must be stable before a drive enters mass production. Contaminants or even lubrication smeared across the platter can pile up on the air bearing surface (“ABS”) of the head. This leads to increased heat and increased flying height (the distance between the ABS and the platter) that destabilize the head and may induce errors in writing and reading data. This is significant because head-related failures, in addition to contamination, was a recurring issue with the Drives.

80. Approximately six months after the release of the SBS Drives, Seagate released the OEM and “disty” Drives. In doing so, it produced another SAD document, which was titled “Grenada SAD Approval 10/18/11.”³⁶

81. This document contains the same type of table as depicted in Figures 8 and 9. Like the previous table, it contains the results of reliability testing conducted with an assumed POH of 2400 hours. It shows that Seagate tested a population of 1360 drives, and the testing revealed that the first-year AFR for the Drive was actually 2.621%, which is approximately **7.7 times** greater than an AFR

³⁶ FED_SEAG0026839.

of 0.34% and approximately **2.64 times** greater than an AFR of <1% (using 0.99% as the AFR). The “demonstrated reduced AFR” was 0.95%, and even this reduced figure was approximately **2.8 times** greater than the advertised AFR of 0.34%. Also note that the failure rate of a hard drive is expected to be constant or slightly decrease during its five year design life. Seagate’s own internal testing of the Drive revealed an increasing, not decreasing, AFR. AFR typically increases when drives begin to wear out as they approach the end of their design life. Early wear out is a hallmark of unreliable products, and are often due to flaws in the design or components.

82. Among the top failures were “degraded head” and “particle induced media damage.” Recording heads degrade mechanically by becoming unstable and coming into contact with the platter. This is commonly known in the industry as a “Head Crash”. Each time an unstable head impacts the platter, the lubrication can pile up on the air bearing surface, the head can get hotter due to friction, and it can render areas of the platter defective for storing data.

G. The AFR of the ST3000DM001 Remained Higher than Advertised

83. Subsequent internal Seagate testing demonstrates that the ST3000DM001 continued to have an AFR greater than that advertised by Seagate, even as the Drive was migrated from the Grenada Classic to subsequent iterations. According to the SAD document for the GrenadaBP, testing conducted on April 12, 2012 revealed a first-year AFR of 2.942% and a “demonstrated reduced AFR” of 2.0%.³⁷ As discussed previously, Seagate’s website advertised the AFR of the ST3000DM001 as “0.34%, <1%” between April 2012 and January 2013 (as well as earlier in the April 2011 Product Manual). Accordingly, Seagate released the GrenadaBP with a first-year AFR that was **8.65 times higher** than the advertised 0.34%, and a reduced AFR that was **5.88 times higher**.³⁸ Moreover, the “potential reduced AFR” was also well in excess of the advertised failure rate, at 1.22%.

³⁷ See GrenadaBP SBS SAD Declare April 18, 2012, FED_SEAG0026867, at 26887.

³⁸ Subsequent testing of the Grenada BP, performed on May 14, 2012, revealed a first-year AFR of 2.917% and a reduced AFR of 0.98%, both of which were significantly greater than the 0.34% advertised by Seagate. See GrenadaBP ECQ Approved Final 6-5-12, FED_SEAG0026751, at 26783. In addition, head-related failures continued to be a problem. For instance, on page

84. Post-release testing of the Grenada Classic, referred to internally at Seagate as Ongoing Reliability Testing (“ORT”), also demonstrated that Seagate was unable to reduce the AFR as time went on. As discussed above, Seagate released the first OEM and “disty” Drives in October 2011 with a first-year AFR of 2.621% and a reduced AFR of 0.95%. Approximately eight months later, on June 4, 2012, Seagate tested the Drive again, discovering that the first-year AFR was 3.436%, which was **10.10 times higher** than the advertised rate of 0.34%.³⁹ This indicates that Seagate’s previous attempts to fix the problems with the Drive were not only ineffective, but that the reliability of the Drive further degraded. Typically, product failure rates decrease over time as the manufacturing process improves. The fact that the Grenada did just the opposite is indicative of a design and/or manufacturing process that was seriously flawed.

85. Since this testing was conducted eight months after the Grenada OEM and “disty” Drives were released, the 3.436% AFR reflected the actual AFR of the Drives purchased by end-users. In addition, Seagate projected a “demonstrated reduced AFR” of 2.35%, meaning that even taking into account the planned corrective actions that Seagate devised for the Drive from their ORT, the Drive’s AFR would still be **6.9 times greater** than the advertised AFR going forward.⁴⁰ Seagate’s AFR went from 2.34% to 2.621% and up to 3.436% within eight months after the start of mass production. This is a strong indication that the Drives were wearing out prematurely.

86. In addition, the Drive was still suffering from head-related failures, which accounted for 19 of the 81 failures that occurred during testing. Simply stated: one quarter of the Drive failures were related to the recording heads.

87. The differences between the AFR demonstrated in internal Seagate testing and the advertised AFR are important to consumers because, unlike most other consumer electronics, if a hard drive fails, the consumer doesn’t just lose a device – they also lose their valuable data: the

FED_SEAG0026757 of the ECQ document, which is a reliability summary, “head instability” is identified as an issue.

³⁹ See GrenadaBP ECQ Approved Final 6-5-12, at FED_SEAG0026785-86.

⁴⁰ See GrenadaBP ECQ Approved Final 6-5-12, at FED_SEAG0026785-86.

1 pictures, email messages, files and programs. Data recovery services can run into the thousands of
2 dollars.

3 88. At the time, an AFR of <1% was considered to be a highly desirable and oft-quoted
4 specification in the storage industry. In my professional experience, <1% is the most frequent AFR
5 specification that I have seen advertised by hard drive manufacturers during this period. Indeed,
6 Seagate touted its desktop, laptop, enterprise, and video storage hard drives as having AFRs of <1%
7 in consumer-facing materials (either by quoting the AFR as “<1%” or a specific figure that was
8 <1%).⁴¹

9 89. A storage device with an AFR >1% would be undesirable because it would not be as
10 reliable as a drive with <1% AFR. Customers care about data, and an AFR of >1% represents an
11 increased opportunity for data loss, when compared to Seagate’s competitors. To this day, an AFR of
12 <1% remains a desirable specification quoted by hard drive manufacturers.⁴²

13 **H. Seagate’s Reliability Testing Underestimated the True AFR of the Drive**

14 90. In addition to the fact that Seagate’s own testing revealed that the AFR was higher
15 than advertised, Seagate’s test results underestimated the true AFR of the ST3000DM001. In
16 projecting the AFR, Seagate utilized a Weibull beta value that reflected the assumption that the
17 failure rate of the Drive would decrease with time, but the failure rate actually increased from an
18 AFR of 2/34% to 2.61% to 3.436% within just eight months after the start of mass production.

19 91. The Weibull distribution is widely used in reliability analysis. In its most general
20 form, the Weibull distribution is a three-parameter distribution. However, a two-parameter version is
21 commonly used. Of the three parameters, the most important parameter is known as beta, or β .

22 92. Beta has a fundamental impact on projected failure rate. The Weibull failure rate as a
23 function of beta is shown below:

24
25 ⁴¹ See July 2012 Storage Solutions Guide, at p.17, 21, 27, 35, available at
26 https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solutions-guide-sg1351-11-1210us.pdf.

27 ⁴² See *How drive reliability is measured and the MTBF of WD drives*, Western Digital,
28 <https://support.wdc.com/knowledgebase/answer.aspx?ID=665> (last accessed November 3, 2017)
(stating that the AFR of Western Digital hard drives is “less than 0.8%.”).

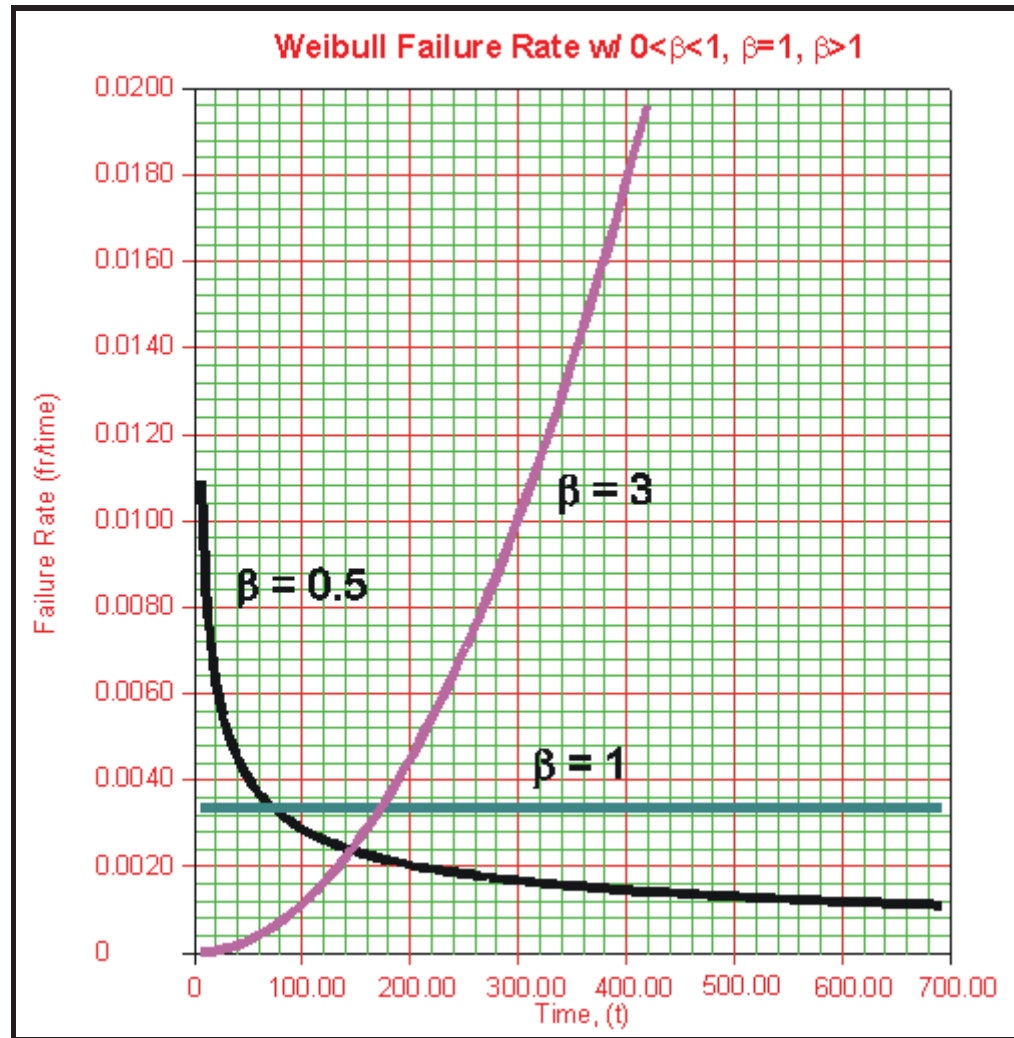


Figure 9: Weibull Failure rate as a function of beta

93. This graph in Figure 9 is widely referred to as a “bathtub curve.” It shows that a β of less than 1 is indicative of a population with a failure rate that decreases over time. This is often referred to as “infant mortality,” because defective products fail quickly and are thus weeded out, leaving a reduced failure rate as time goes on. A β of around 1 indicates a constant failure rate and would reflect the useful life of a product with random failures. Finally, a β of more than 1 indicates that the failure rate is increasing with time and that the product is wearing out.

94. As discussed in Section F, Seagate computed a β of 0.608098 (i.e. a value of less than one) for the release of the Drive to Seagate Branded Solutions customers. Seagate also computed a β of less than one for all of the other reliability testing it conducted. This β value represents an assumption that the Drive will have a declining failure rate over time.

95. However, Seagate's testing was flawed because the failure rate of the ST3000DM001 did not decline with time, but rather increased from an AFR of 2.34% to 2.621% to 3.436% within just eight months after the start of mass production. Seagate should have used a β value greater than 1, rather than 0.608098, to accurately represent their failure rate.

96. In June 2012, nearly a year after the initial release of the Drive and 12 days after the results of ongoing reliability tests showed a greater-than-advertised AFR, Andrei Khurshudov, Ph.D, Senior Director of Cloud Storage Quality Engineering for Seagate, wrote a report that seriously questioned the validity of Seagate's modeling. An email introducing the report is shown below:

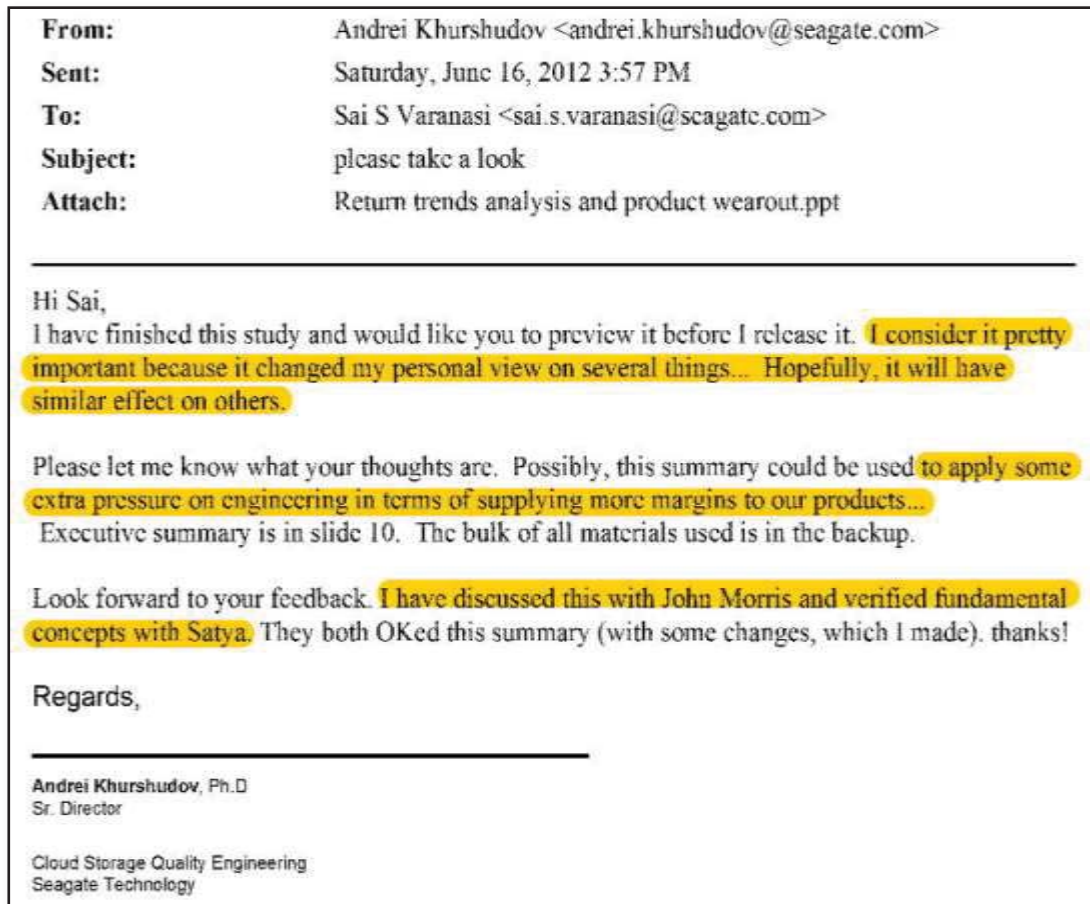
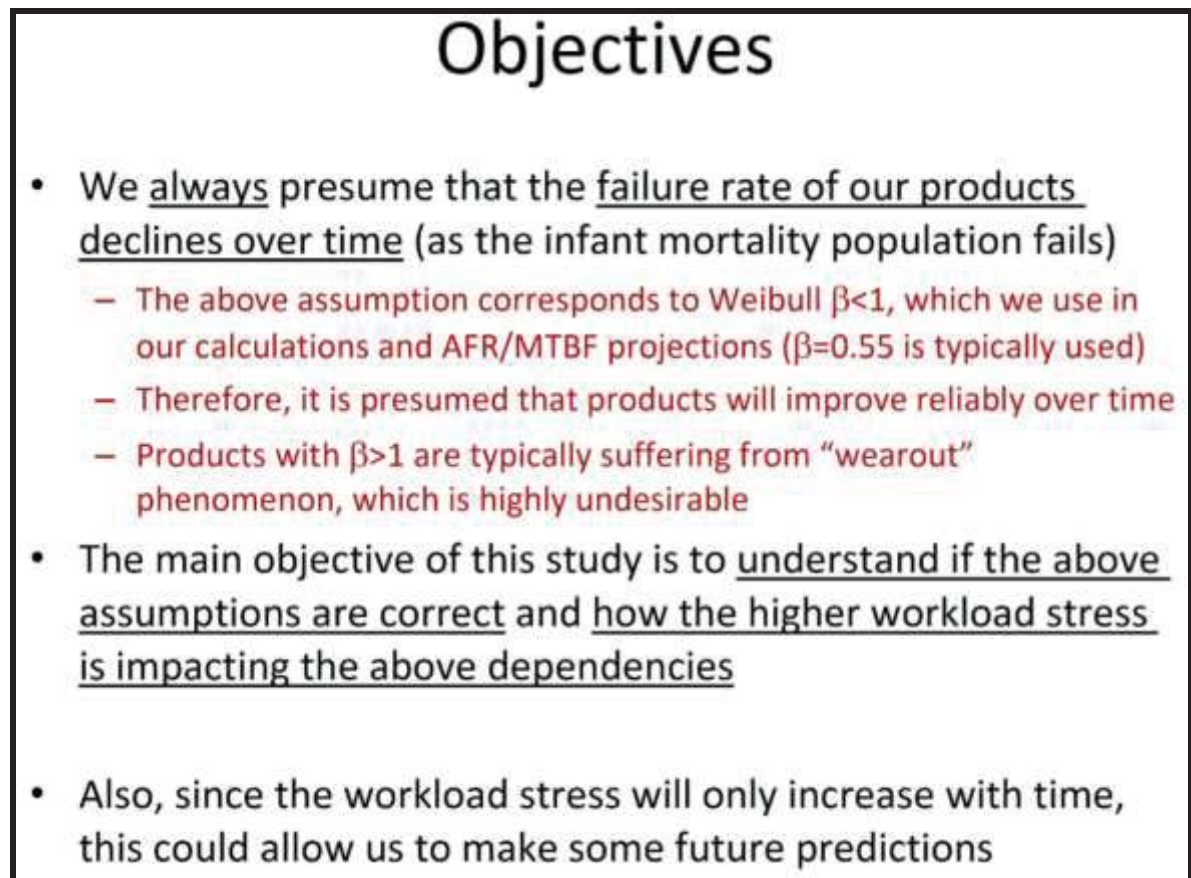


Figure 10: Email from Andrei Khurshudov (FED_SEAG0001817) (highlights added)

1 97. Dr. Khurshudov shared his report and sought feedback and approval from at least five
 2 people at Seagate, including the Vice President of Quality, Michael Crump, who was Dr.
 3 Khurshudov's superior.⁴³

4 98. As shown in Figure 10, above, Dr. Khurshudov concluded that his summary "could be
 5 used to apply some extra pressure on engineering in terms of supplying more margin to our products
 6" (ellipsis in original). To see why Dr. Khurshudov would make such a critical statement of
 7 Seagate's design practices, it is necessary to turn to the details of his report, which was produced as
 8 FED_SEAG0001851-81.⁴⁴ The report is in the form of a PowerPoint presentation and is titled
 9 "Product Failure Rate Trends and the Role of Workload Stress." The second slide of the presentation
 10 is reproduced below.



25 *Figure 11: Objectives of Dr. Khurshudov's analysis (FED_SEAG0001852)*

26 ⁴³ Khurshudov Dep. at 131:5-17, 137:1-138:6.

27 ⁴⁴ It is my understanding that this was the most recent version of Dr. Khurshudov's report that
 28 Seagate has produced. Dr. Khurshudov emailed the report to a Seagate manager on June 17, 2012.

99. Dr. Khurshudov is thus examining a fundamental assumption that Seagate makes about the reliability of its drives and how they fail over time. Note the references to the Weibull distribution and an assumption that β is less than 1, with a typical value of 0.55 (recall that the Weibull β for the ST3000DM001 when it was first approved for release was 0.608098, and it was less than 1 for every subsequent test).

100. After providing background information about what the different β values mean (i.e. increasing, decreasing, or constant failure rate), Dr. Khurshudov explained his methodology using data from eCube, the Seagate's database that stores information about returns. Importantly, his analysis covered a typical period of 36 months' worth of shipments. Dr. Khurshudov then presents a chart showing how each generation of product is exhibiting failures rates consistent with β increasing to and possibly surpassing a value of 1. This chart is shown below.

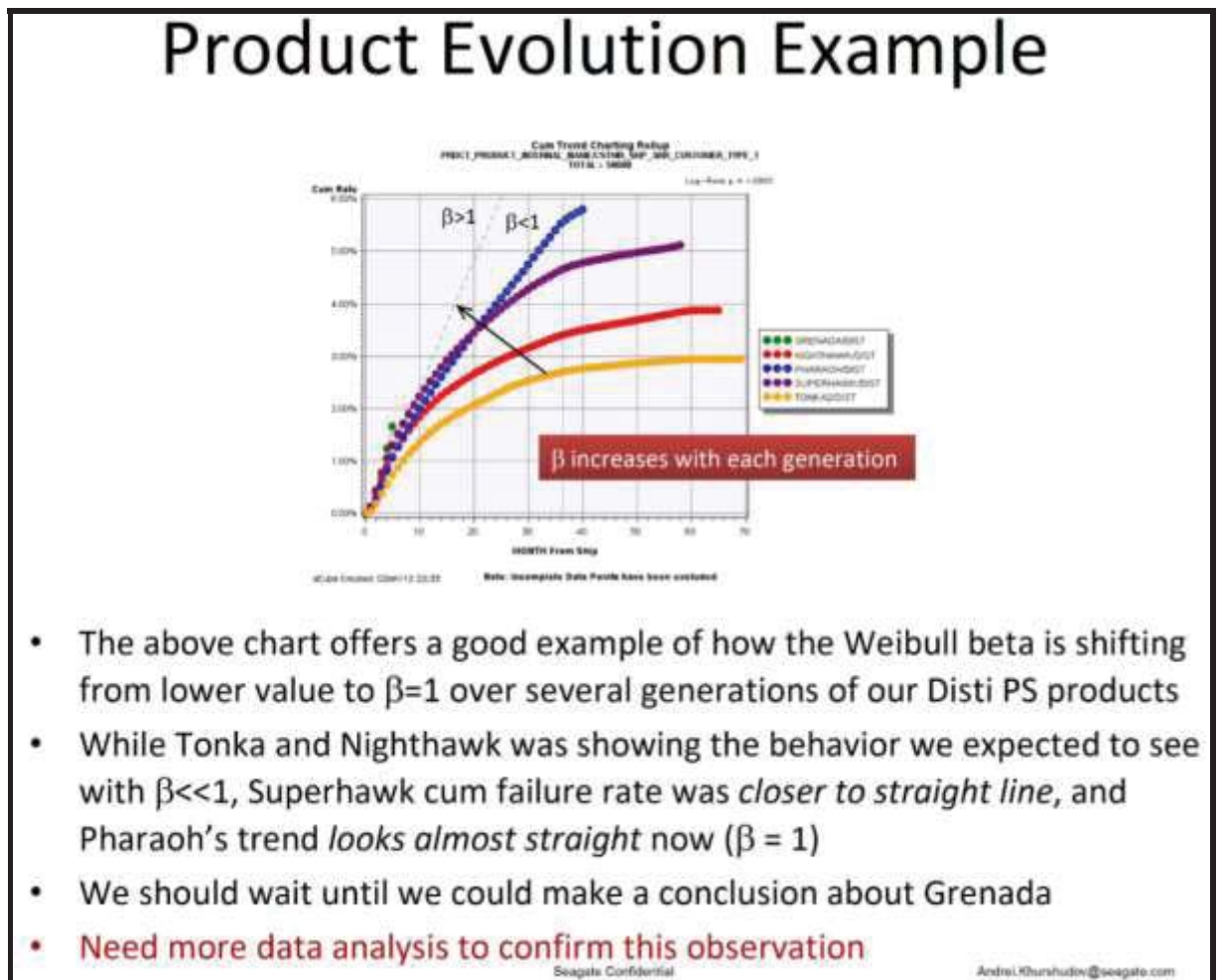


Figure 12: Dr. Khurshudov showing how β is changing with drive generation (FED_SEAG0001857)

101. Grenada (in green) was the most recent generation and appears to have had the worst performance (largest β). Note, however, that Dr. Khurshudov was not comfortable drawing conclusions about Grenada until he had more than just six months data, but it appears that he did not later update the report. Notwithstanding this, the graph shows a clear progression from $\beta < 1$ to $\beta > 1$, with the data points of the Grenada falling in the $\beta > 1$ range.

102. Dr. Khurshudov provides additional information on wear out modes and then produces his conclusions, which are shown below.

Conclusions

- About 50% of our products do not follow an expectation of declining failure rate (or, $\beta < 1$) with time. 30% of products show a signature of wearout.
 - This could serve as an evidence that our products don't have enough design margin
- It is possible that there is a correlation between the amount of workload stress and the product's propensity to show constant failure rate or wearout
 - MC and NL products, operating under higher workloads, show many more signatures of constant failure rate or even wearout than less stressed NS and SBS products
 - High workload seems to prevent failure rate from declining over time
 - More "focused and formal" analysis is needed to confirm this dependence
- Future will bring higher workload stress and, thus, higher risk of wearout
- Also, considering that we observe $\beta < 1$ in most of our internal tests (RDT, ORT), one could conclude that these relatively short tests do not necessarily predict well the long-term product reliability behavior
- The Weibull β values assumptions we are using for AFR/MTBF projections might need to be revisited upward to, possibly, $\beta = 1$.
- Longer-term reliability tests (~1 Year) might need to be introduced to gain more confidence in reliability projections

Seagate Confidential
Andrei.Khurshudov@seagate.com

Figure 13: Dr. Khurshudov's conclusions (FED_SEAG0001860)

103. Whilst all of the conclusions are important, there are few that are particularly germane. First, Dr. Khurshudov concluded, "About 50% of our products do not follow an

1 expectation of declining failure rate (or, $\beta < 1$) with time . . . This could serve as an (sic) evidence that
2 our products don't have enough design margin."

3 104. This was a general statement about Seagate's products and was not aimed at the
4 ST3000DM001 in particular. However, the Backblaze reports showed that certain Seagate products,
5 and the ST3000DM001 in particular, were not as robust as the competition. For example, a report
6 published by Backblaze in 2015 revealed that the ST3000DM001 Drives deployed at Backblaze
7 experienced shockingly high failure rates that were substantially higher than the other 3TB hard
8 drives Backblaze used. Specifically, the ST3000DM001's overall failure rate was 28.46% from 2013
9 to 2015, with a huge spike from 10.35% to 43.08% between 2013 and 2014 (most of the
10 ST3000DM001s used at Backblaze were deployed in 2012).⁴⁵ The 3TB drive with the second highest
11 failure rate was the Western Digital Red, at 7.65%.⁴⁶

12 105. In short, it is my professional opinion that, as to the ST3000DM001, Dr.
13 Khurshudov's statement was correct.

14 106. Next, Dr. Khurshudov concluded:

15 Also, considering that we observe $\beta < 1$ in most of our internal tests
16 (RDT⁴⁷, ORT⁴⁸), one could conclude that these relatively short tests do
17 not necessarily predict well the long-term product reliability behavior.
(Emphasis in original.)

18 107. This acknowledges that Seagate used predictive tests that were overly optimistic
19 about the reliability of Seagate hard drives.

22 ⁴⁵ See *What Can 49,056 Hard Drives Tell Us? Hard Drive Reliability Stats for Q3 2015*,
23 Backblaze (Oct. 14, 2015), <https://www.backblaze.com/blog/hard-drive-reliability-q3-2015>
24 (hereafter "October 2015 Report"); FED_SEAG0025567, at 25571 (internal Seagate document
25 stating that the AFR of the ST3000DM001 at Backblaze was 43.10%). See also *CSI: Backblaze –*
26 *Dissecting 3TB Drive Failure*, Backblaze (April 15, 2015), [https://www.backblaze.com/blog/3tb-](https://www.backblaze.com/blog/3tb-hard-drive-failure)
27 *hard-drive-failure*; *How long do disk drives last?*, Backblaze (Nov. 12, 2013),
28 <https://www.backblaze.com/blog/how-long-do-disk-drives-last/>.

⁴⁶ See October 2015 Report, *supra* n.40.

⁴⁷ RDT = Reliability Demonstration Test

⁴⁸ ORT = Ongoing Reliability Testing

1 108. Dr. Khurshudov also concluded, “Longer-term reliability tests (~1 Year) might need
2 to be introduced to gain more confidence in reliability projections.” Seagate tested its hard drives to
3 around 1008 hours, which is six weeks.⁴⁹

4 109. Additionally, Dr. Khurshudov concluded that, “The Weibull β values assumptions we
5 are using for AFR/MTBF projections might need to be revisited upward to, possibly, $\beta = 1$.” I agree
6 with Dr. Khurshudov that the assumed The Weibull β values should have been changed to reflect the
7 projected and observed reliability of the Drives.

8 110. A prior version of Dr. Khurshudov’s report reached an even stronger conclusion. This
9 version, which was attached to an internal Seagate email from Dr. Khurshudov dated June 1, 2012,⁵⁰
10 stated that “The Weibull β constant assumptions we are using for AFR/MTBF projections might
11 need to be revisited upward to, *at least*, $\beta = 1$.”⁵¹ Dr. Khurshudov changed this conclusion from “*at*
12 *least*, $\beta = 1$ ” to “*possibly*, $\beta = 1$,” and made some of his other conclusions “more careful and less
13 certain” to avoid “conflict” with his colleagues at Seagate who might have taken exception to him
14 criticizing their testing methods too bluntly.⁵²

15 111. In any event, Dr. Khurshudov’s call to increase the Weibull beta value used for
16 projecting AFR indicates that Seagate’s method of calculating failure rates underestimated the rate at
17 which Seagate products incurred wear-out failures.⁵³

18
19
20 ⁴⁹ See Almgren Dep. 187:24-188:17.

21 ⁵⁰ See FED_SEAG0001985.

22 ⁵¹ See FED_SEAG0001986, at 1993.

23 ⁵² See Khursudov Dep., at 164:7-165:22.

24 ⁵³ Other internal documents from 2012 acknowledge that Seagate’s design and reliability
25 validation processes failed to ensure that products met service life goals and customer expectations.
26 See FED_SEAG0055831; FED_SEAG0056341; FED_SEAG0068026; FED_SEAG0056259. In an
27 internal proposal titled “5-year BiC service life Strategic Reliability Initiative,” Seagate specifically
28 acknowledged it had a “Reliability Challenge” and considered making specific changes to, among
other things, raw MTBF metrics, design margin testing, life testing and validation, SBS Design
Maturity Test requirements, defective parts per million demo quantity requirements, and the
firmware release process. FED_SEAG0055831, at 55838, 55848. In that same document, Seagate
identified “NHK particulate contamination,” “Head instability,” and “DSP tolerance to MBA” as the
main problems with the Grenada. FED_SEAG0055831, at 55841.

112. It appears that Seagate did not implement reliability tests for the ST3000DM001 that were significantly longer than six weeks, nor did it utilize a β value of one or greater. The below figure is part of a table reporting the results of reliability testing on the Grenada BP2, which was released on or around January 15, 2014.



Figure 14: Grenada BP2 reliability test results (FED_SEAG0057277, 57324)

113. Here, Seagate tested 1058 Drives for an average of 1197 hours, which is approximately seven weeks, and the Weibull β was 0.394. Unlike prior reliability testing, Seagate projected the AFR for the first through fifth years, rather than just the first year, and the AFR increased from 1.039% in the first year to 1.951% in the fifth year.

114. I cannot reconcile this increasing failure rate with the use of a Weibull β of 0.394, because a β of <1 reflects a decreasing failure rate. The fact that Seagate came up with a β of >1 , projecting an increasing failure rate, further suggests that Seagate's testing was deeply flawed. In any event, the increasing AFR demonstrates that the ST3000DM001 was projected to have significant wear-out failures within its five-year expected service life. If a β of greater than one had been used, it is likely that the projected AFR would have been even higher.

115. The increasing failure rate also indicates that the first-year AFR projections used in the previous reliability tests substantially underestimated the true AFR of the ST3000DM001 over its

1 expected life. Projecting only the first-year AFR is appropriate when the failure rate of a product
2 decreases over time, but that was not the case with the ST3000DM001.

3 116. Notably, the top “issue” in the above chart is related to contamination, and the third
4 issue is head-related.

5 117. In summary, since the failure rate of the ST3000DM001 increased with time, the
6 Weibull beta of <1 that Seagate used in projecting the AFR of the Drive was not correct. The
7 Weibull beta should have been >1 . This, in conjunction with the fact that Seagate only calculated
8 AFR for the first year of Drive use until the Grenada BP2 was tested, means that Seagate
9 underestimated the AFR of the Drive. Accordingly, the true AFR of the Drive was likely appreciably
10 higher than the values projected by Seagate during the pre-release and post-released testing discussed
11 above. Moreover, contamination and head-related failures continued to plague the ST3000DM001 at
12 the time the GrenadaBP2 was released.

13 **I. The ST3000DM001 was Unstable and was Released Prematurely**

14 118. The ST3000DM001 was not only sold by Seagate with an AFR that was significantly
15 higher than what Seagate advertised, but the Drive was unstable, defective, and was released
16 prematurely. Seagate was aware of such, evidenced by the Drive’s low factory yield, its large
17 number of engineering and firmware changes, its repeated shipping holds, its escalating reliability
18 issues, and internal Seagate communications, among other things.

19 **1. The ST3000DM001 Had a Very Low Yield**

20 21 119. The term “yield” refers to the number of good, shippable units that are produced at a
22 factory, as opposed to units that are discarded or sent to be reworked because they were discovered
23 to be defective or did not otherwise meet quality control standards. There is a relationship between
24 factory yield and reliability; a low factory yield is indicative of an unreliable, defective product.
25 When producing millions of drives, a factory yield below 90% is a cause for concern because
26 humans are required to diagnose, repair and rework hundreds of thousands of defective disk drives.

6H Yield	56.0	56.0	63.9	65.0	65.0	65.0	68.0	68.5
3TB LRP	54.2	54.5	54.7	54.7	54.7	56.0	56.0	56.2
3TB Task	54.2	54.5	54.7	54.7	54.7	60	60	60.4
Meeting Current LRP								

Figure 16: Portion of chart from page entitled “Grenada YIP [Yield Improvement Plan] Migration” (FED_SEAG0026839, at 26856)

125. This chart contains yield information for the ST3000DM001 in the “6H Yield” row,⁵⁴ and it reveals that, over the course of several weeks, the yield of the ST3000DM001 was, at most, 68.5%. While this is an improvement on the previous yields, it is still very low, and means that nearly a third of the Drives Seagate produced required rework or corrective action. Thus, although six months had elapsed since the first release of the ST3000DM001, Seagate was unable to increase first pass yields to a level in the 90-99% range more typical of the storage industry.

126. As discussed above, on April 18, 2012, Seagate authorized the release of the GrenadaBP. In the “GrenadaBP SBS SAD Declare April 18, 2012” document, on FED_SEAG0026872, the yields for the 3TB Grenada BP over a ten-week period were between 56.6% and 71.8%. Moreover, this document listed the yields for the 3TB Grenada Classic as between 68% and 70.4%. At this point, Seagate is reworking or taking correction action on at least a quarter of the Drives they are producing.

2. The Engineering Change Logs Also Evidence that the Drive Was Unstable and Shipped Prematurely

127. Seagate produced Engineering Change Request (ECR) data for the Grenada Classic in the form of a spreadsheet. This spreadsheet is a log of all of the changes made to the electrical and mechanical components of the Drive, among other things. An example of what the data looks like is shown below:

⁵⁴ “6H” stands for six heads, which was the number of heads the ST3000DM001 had.

	A	E	F	G	H	I	L	M	N	O
1	Name	Project Name	Disposition	Priority	Reason	Change Duration	Description (WbsDescription)			
2	ECR0120493, SEA GRENADA CC	Approved	Serious Priority	Initial Release	Permanent	***NOTE - 3/2/10 Removed alternate PCBA				
3	ECR0123019, SEA GRENADA CC	Approved	Serious Priority	Initial Release	Permanent	ECR creates evaluation CCs for Grenada 1D,				
4	ECR0123457, SEA GRENADA CC	Approved	Serious Priority	Commonality	Permanent	REASON FOR CHANGE: There is a bug in the				
5	ECR0124045, SEA GRENADA CC	Approved	Serious Priority	Initial Release	Permanent	Support FIS tracking of 900 and 750GB capaci				
6	ECR0125047, SEA GRENADA CC	Approved	Serious Priority	Initial Release	Permanent					
7	ECR0125054, SEA GRENADA CC	Approved	Serious Priority	Allow Purchase/Build of Eva	Permanent	Structure GRN13 and GRN15 PCBAs to CCs as				
8	ECR0126175, SEA GRENADA CC	Approved	Serious Priority	Allow Purchase/Build of Eva	Permanent	Revise the following -997 CCs: 9GL16C-997 (5				
9	ECR0128201, SEA GRENADA CC	Approved	Serious Priority	Allow Purchase/Build of Eva	Permanent	Adding latest released GRN15 and GRN16 PC				
10	ECR0128308, SEA GRENADA CC	Investigate	Serious Priority	Allow Purchase/Build of Eva	Temporary	CANCELED BY FACTORY - NO LONGER NEEDED				
11	ECR0128512, SEA GRENADA CC	Approved	Serious Priority	Document update	Permanent	***NOTE: PREREQUISITE ECR0128511 TO UPD				
12	ECR0129117, SEA GRENADA CC	Approved	Serious Priority	Inactivate CCs	Permanent	SEA GRENADA CC Due to out of order 3 cha				
13	ECR0129310, SEA GRENADA CC	Approved	Serious Priority	Document update	Permanent	For the following CCs: 9YN162-999 9YN164-				
14	ECR0130185, SEA GRENADA CC	Approved	Serious Priority	Change Status of BI	Permanent	Per Grenada Program Management, change				
15	ECR0131159, SEA GRENADA CC	Approved	Serious Priority	Initial Release	Permanent	Initial Release of 1D HDD/PCBA drawing, DO				
16	ECR0131485, SEA GRENADA CC	Approved	Critical Priority	Initial Release	Permanent	Grenada SBS initial release 1, 2 & 3TB witho				
17	ECR0132000, SEA GRENADA CC	Approved	Serious Priority	Label Update	Permanent	This ECR updates the Grenada Std product ID				
18	ECR0132124, SEA GRENADA CC	Approved	Critical Priority	Customer Unique Code CC	Permanent	BLANKET APPROVAL REQUESTED - WILL USE				
19	ECR0132316, SEA GRENADA CC	Approved	Serious Priority	Document update	Permanent	Revise 9YN164-568 since "TV_5W_REV" has b				
20	ECR0132317, SEA GRENADA CC	Approved	Serious Priority	Customer Unique Code CC	Permanent	BLANKET APPROVAL REQUESTED! -----				
21	ECR0132566, SEA GRENADA CC	Approved	Critical Priority	Consume Inventory	Temporary	BLANKET APPROVAL REQUESTED! -----				
22	ECR0132567, SEA GRENADA CC	Approved	Serious Priority	Initial Release	Permanent	Grenada Disty BOMs initial release 9YN166-				

Figure 17: Example of ECR data, FED_SEAG0027240

128. Figure 17 shows some of the key fields including the ECR's disposition, priority, reason for issuance, its duration (permanent / temporary) and its description. Note that I have hidden some fields that are of lesser importance. The following table summarizes the frequency and type of ECRs that were generated.

	Count	Percentage
Total number of ECRs:	1023	
ECR's that are minor	3	0.3%
ECR's that are serious	964	94.2%
ECR's that are critical	40	3.9%
ECR's that are emergency	16	1.6%
ECRs that are permanent changes	805	78.7%
ECR's that are CC	416	40.7%
ECR's that are electrical	151	14.8%
ECR's that are mechanical	456	44.6%
ECR's that are approved	956	93.5%
ECR's that are disapproved	11	1.1%
ECR's that are 'None'	33	3.2%
ECR's that are 'investigate'	23	2.2%

	Count	Percentage
CC ECRs after product release	382	91.8%
Electrical ECRs after product release	54	35.8%
Mechanical ECRs after product release	283	62.1%
All ECR's after product release	719	70.3%

Figure 18: Summary of Grenada Classic ECR Data

129. Below I list some noteworthy observations from Figure 18:

- a. 70.3% of ECR's occurred after the Drive was released for mass production
- b. Almost all ECR's were at least "serious."
- c. Most ECRs were approved.
- d. 78.7% of ECRs were marked as permanent. The remaining 21.3% of the ECRs were called "TEMP DA" or "Temporary Deviation Authorization" by Seagate.
- e. Most Customer Code (CC) ECRs occurred after Grenada was approved for production, including 54 electrical ECRs.
- f. One third of electrical ECRs occurred *after* Grenada was released to production.
- g. Almost two thirds of mechanical ECRs occurred *after* Grenada was released to production. This represented 283 changes.

130. These are significant because mature and stable products, tend to have very few changes post-release, and the changes that are made are typically permanent. Thus, a large number of post-release changes is indicative of an unstable product, and a large number of temporary changes is indicative of quick fixes that are made to keep the production line running. For the ST3000DM001, the number of post-release changes were staggering, and a substantial percentage of them were designated as temporary.

131. The following graph shows ECR data plotted by month.

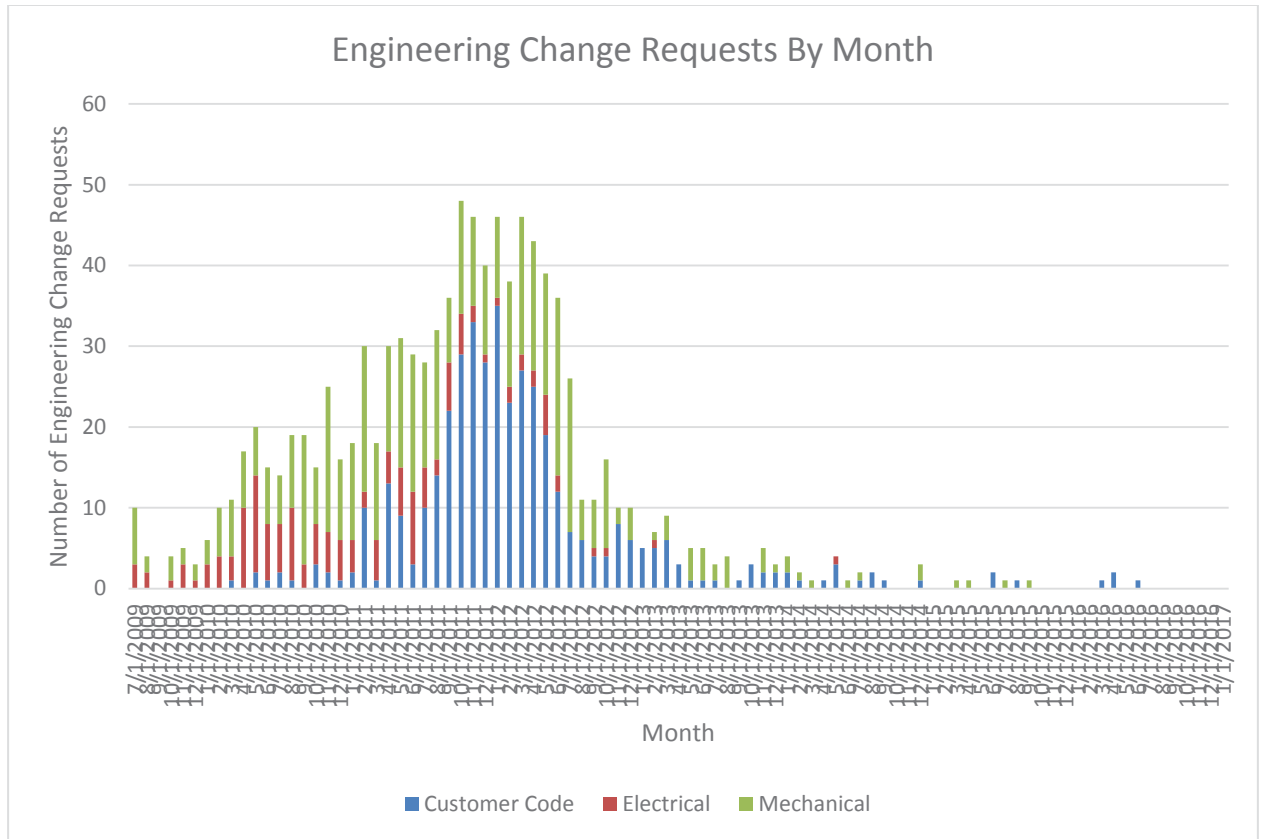


Figure 19: Graph of Grenada Classic ECR by month

132. The X axis is difficult to read in Figure 19 and the graph in Figure 20 below expands the first few years ECRs. The yellow highlighting at 5/1/2011 shows approximately when Grenada Classic was released into mass production.

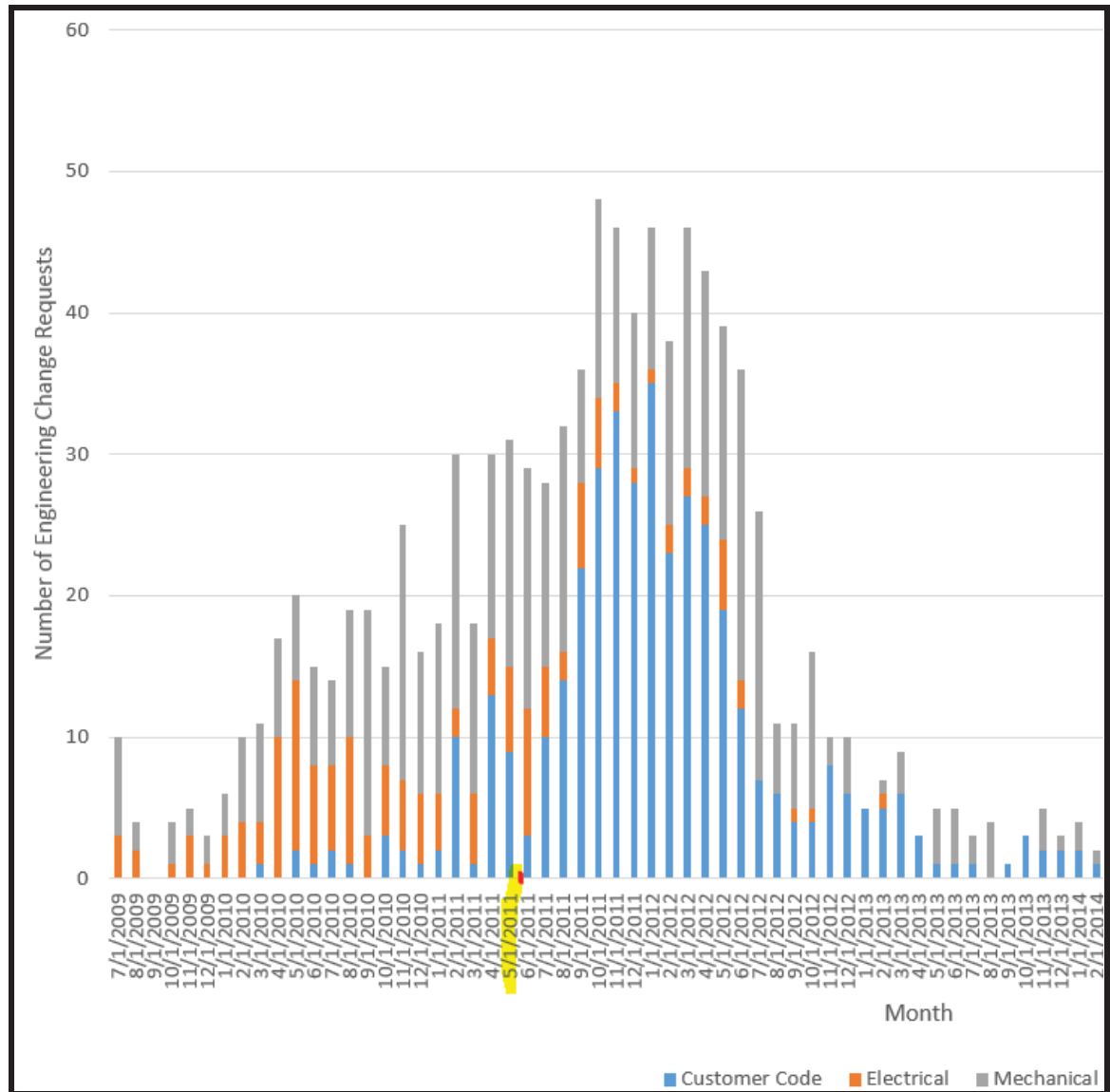


Figure 20: First few years of Grenada Classic ECR

133. The above graph shows that in the year following the initial release of the Drive, at least 30 ECRs were raised every month, and for much of that time there were more than 40 ECRs raised each month. This means that on average, an ECR was raised every single day for a year.

134. Although not all ECRs are related to reliability, the evidence supports my opinion that Seagate's reliability testing and quality control mechanisms were deeply flawed, which resulted in a highly unstable product that was shipped prematurely. I address the specifics of some of the ECRs below.

135. Chris Labbe, Senior Director of Analysis and Solutions Engineering, wrote the following email in October 2012 stating “**Grenada is not very stable right now.**” (emphasis mine).

From: **Chris G Labbe** <chris.g.labbe@seagate.com>
 Date: Sun, Oct 21, 2012 at 9:13 PM
 Subject: Re: Agenda for QIR Executive Reviews, Oct 30-31
 To: Andrei Khurshudov <andrei.khurshudov@seagate.com>

Here's our daily report on the 90 day inventory of failures by source.

Mostly, the operation of concern is CST2, which indicates the QA version of GIO, usually run as LODT.

In the recent history, Grenada is the highest volume by far. **But Grenada is not very stable right now.** It could be a good study since it would represent the extreme ... could we still catch the existing problems even with nearly constant shifts in performance.

Otherwise, Pharaoh is the other candidate. More mature and stable. If sampling doesn't reveal the same answer here, then it might not on any other program :)

Figure 21: FED_SEAG00006442 (highlight added)

136. The Grenada BP also had an unusually high number of ECRs. The Grenada BP had 732 ECRs, of which 13 were “Emergency,” 19 were “Critical,” and 696 were designated as “serious.” A mere 3 ECRs were designated as “Minor.”⁵⁵ In my experience, this means that the problems with the Drive continued, and it was still an immature and unstable product.

a. Electrical ECRs

137. The following examples of electrical ECRs applicable to Grenada Classic provide an understanding of the stability of the electrical design. The sheer number of issues is not the sign of a mature product design that is ready for mass production.

138. ECR0133245 was raised on March 8, 2011, about 6 weeks before the ST3000DM001’s first shipping approval. This ECR, which was designated as “Serious priority” and “Improvement- Design Engineering,” pertained to burnt switching regulators that control power on the Drive. Shortly before the Drive was to be put into production, Seagate discovered that it had made a significant design mistake around a switching regulator which could result in the regulator

⁵⁵ FED_SEAG0027241.

1 being burnt. Switching regulator circuits are not trivial to design, so a blunder of this magnitude at
2 this stage of development is remarkable.

3 139. On May 10, 2011, two weeks *after* the ST3000DM001 was first released to
4 production, ECR0135418 was raised and designated as “Critical Priority” and “Improvement-
5 Design Engineering.” It pertained to a step-down regulator, which is used to convert a higher input
6 voltage (such as 5V) down to a lower output voltage (such as 3V). With these types of devices, the
7 output voltage is set via the use of a resistor divider network.

8 140. This ECR was raised to change the value of the resistors that make up the feedback
9 network. It is unclear from the ECR description whether Seagate changed the output voltage (which
10 would be enormously significant) or integrated an alternate part that needed a slight tweak to the
11 resistors. Regardless, it is quite remarkable that a change of this type would be made two weeks after
12 the product was released into mass production because such a change is normally processed months
13 before a product is released to manufacturing.

14 141. Two days after the above ECR, ECR0135564 was raised. It was given a “Serious
15 Priority” and was classified as “Improvement - Manufacturing Process.” This ECR concerns the
16 reduction of solder height on the bare printed circuit boards used in the ST3000DM001.

17 142. It is not particularly clear from the ECR, but the way in which solder height would be
18 reduced is via changes to the solder stencil aperture, which is a manufacturing device that controls
19 the application of solder paste. It is critical that the correct amount of solder paste is applied to the
20 printed circuit board, as too much or too little will lead to poor connections. Thus, the correct design
21 and sizing of the solder stencil aperture is a critical step in ensuring a high quality printed circuit
22 board assembly. Again, it is remarkable that within a couple of weeks of the ST3000DM001 being
23 approved for shipment, Seagate needed to change such an important part of the printed circuit board
24 manufacturing process. Problems of this type are normally ironed out as part of a pre-production
25 phase.

26 143. The above examples demonstrate that the electrical design was still in a state of flux
27 when the ST3000DM001 went into mass production and was approved for shipment.

b. Mechanical ECRs

144. Following are examples of the mechanical ECRs raised Grenada Classic.

145. On August 3, 2011, ECR0138496 was raised to allow for “Initial Release & Structure of NHK 4.5 HSAs.” The HSA is the Head Stack Assembly that contains the recording heads, positioning arm, and servo motor windings. A picture of a typical HSA is shown below:



Figure 22: An example of a Head Stack Assembly.⁵⁶

146. The HSA is a major component of a HDD, so it was unusual to see a new HSA design being introduced to the Grenada product line only four months into mass production. In fact, the HSA must be a stable to mass produce reliable hard drives. Redesigning the HSA after the first quarter of production suggests the Drive was not ready for production with its original HSA. Many of the other mechanical ECRs are also related to either the HSA or HDA (Head Disk Assembly) areas.

147. Another major mechanical issue concerned tolerance issues with the Disk Separator Plate (“DSP”). On May 31, 2012, there was a “hold” related to the DSP. A hold is put into place when a defect is discovered or a hard drive or hard drive component otherwise exceeds the manufacturer’s “trigger limits” for AFR, MTBF, defective parts per million, or some other reliability metric. A hold can be a shipping hold, which is a freeze on the shipment of the hard drive from one

⁵⁶ See MjM Data Recovery Ltd., Head Stack Assembly, <https://www.mjmm.co.uk/hard-disk-disassembly/hard-disk-head-stack.html> (last accessed October 9, 2017).

or more factories, or a build hold (sometimes referred to as a “stop build”), which is a freeze on building the hard drive with a specific part.

148. The DSP hold was put in place due to a mechanical mismatch between the DSP and a component called the motor base assembly (“MBA”), such that the DSP became warped after putting in the DSP screw. A diagram of the DSP and MBA is below.

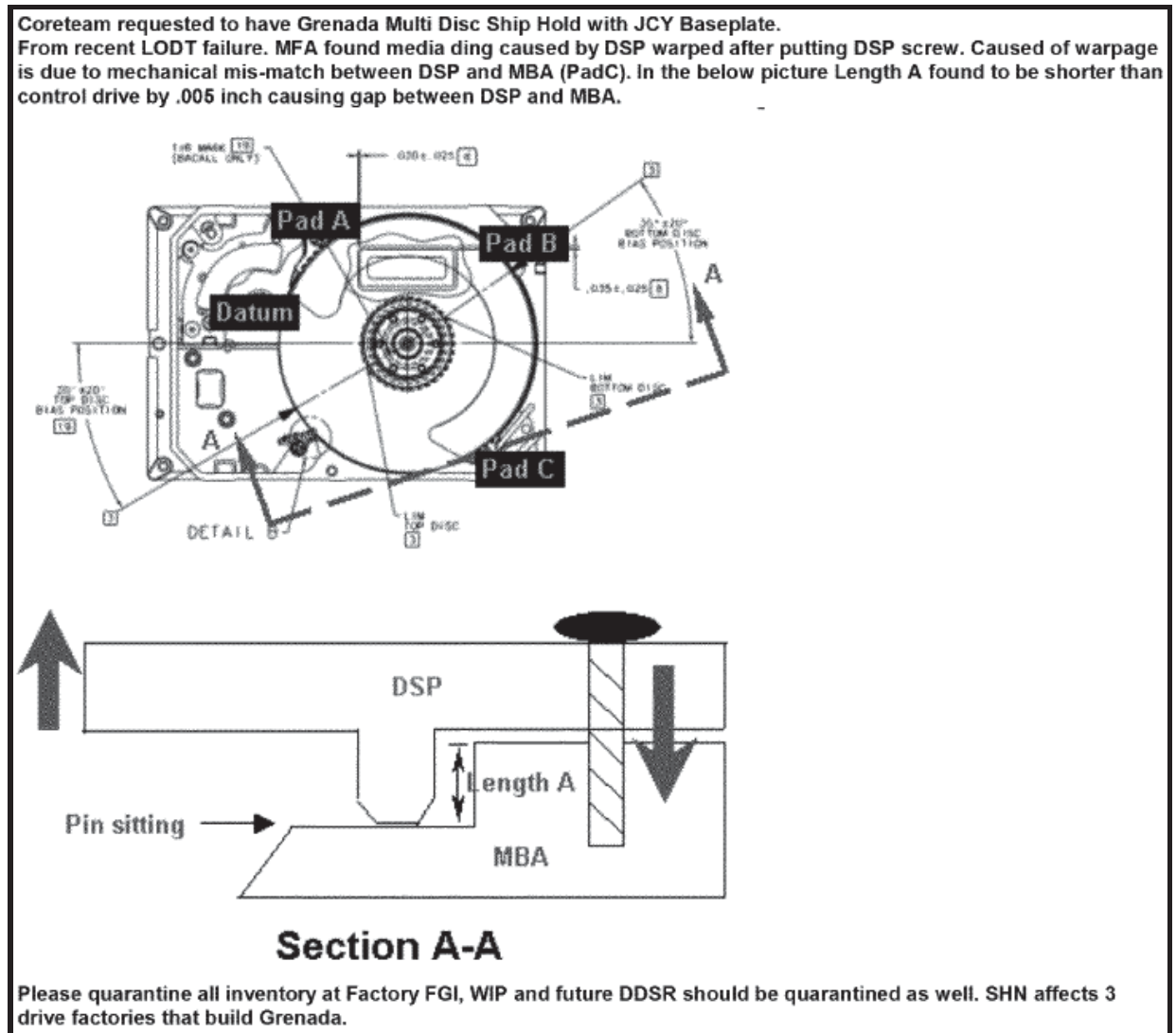


Figure 23: Details on DSP Tolerance Problem. FED_SEAG0008927, at 8928

149. The DSP at issue had been in use since 2010 and was used in the ST3000DM001’s early development phases.⁵⁷ It was also used in two drives that preceded the release of the ST3000DM001, which were codenamed “Trinidad” and “Bogart.” The fact that it took Seagate two

⁵⁷ Grenada BP ECQ Approved Final 6-5-12, FED_SEAG0026751, at 26781.

1 years to discover the problem is remarkable, especially considering the DSP was used in multiple
2 hard drives.

3 150. In response to the problem, on June 1, 2012, ECR0148346 was raised as “Serious
4 priority”, “Improvement - Design Engineering” and “Permanent.” This ECR called for the use of
5 reworking / modification of existing parts, followed by a switch to a new part to eliminate the
6 mechanical mismatch between the DSP and the MBA.⁵⁸

7 151. However, this was not the end of this saga. On June 25, 2012, ECR 0149074 was
8 raised. This ECR stated:

9 ECR0148346 [the ECR discussed immediately above] was pushed
10 through as urgent with the understanding that PN 100694007 was only
11 a few days away from being fully qualified. It’s been several weeks
and the part is still not qualified, thus it is being removed from the
BOMs and ECR0148346 is being backed-out!⁵⁹

12 152. Generally, a part becomes “qualified” when testing demonstrates that it meets the
13 applicable requirements imposed by the hard drive manufacturer. Here, a non-qualified part was
14 rushed through as urgent to address the DSP issue on the understanding that it would be qualified
15 within a few days. Twenty-four days later (and thus presumably after 24 days of the Drive being
16 shipped with a non-qualified part), this ECR was raised to stop the Drive from being built with the
17 unqualified part.

18 153. However, even this was not the end of the situation because a few weeks later, on July
19 12, 2012, Temporary DA ECR0149636 was generated. This ECR stated, in part:

20 ECR0149636, Grenada: TEMP DA allow ship 26K drives w/DSP PN
21 100694007 to Disty . . . Allow ship of 26K drives with DSP PN
100694007 to Disty only⁶⁰

22 154. Thus, this ECR was asking for permission to ship 26,000 Disk Drives with the same
23 (presumably still unqualified) part to “disty” customers. This ECR was approved. In essence, “disty”
24

25 ⁵⁸ FED_SEAG0027240 at row 923.

26 ⁵⁹ This same part number turns up again in ECR0150131 (July 27, 2012). In fact, this one part
27 was the topic of no less than seven ECRs spread over the dates December 2011 to July 2012. See
FED_SEAG0027240 rows 848, 919, 923, 941, 957, 962 and 982.

28 ⁶⁰ FED_SEAG0027240 at row 957

1 was used as a dumping ground for Drives with unqualified parts. As explained below, this is not the
2 only example of Seagate shipping Drives to “disty” or SBS customers that it deems unfit for
3 shipment to OEMs.

4 155. Although mechanical tolerance analysis used to be a difficult and challenging task,
5 today, and at the time the ST3000DM001 was being produced, modern computer tools, such as
6 computer-assisted design software, make it an almost trivial task. The fact that it took two years for
7 Seagate to discover the DSP tolerance issue suggests that a mechanical tolerance analysis was not
8 performed, was performed carelessly, or the results were ignored. It further demonstrates the
9 ineffectiveness of Seagate’s reliability testing and quality control processes, and underscores
10 Seagate’s willingness to rush hard drives and hard drive components into production.

11 **c. A Plethora of Firmware Versions Were Released**

12 156. Firmware is software that controls the basic functions and operations of a device. In
13 the context of hard drives, the firmware executes requests to read or write user data, performs
14 diagnostics and manages defects. For some products, the firmware is permanent and cannot be
15 changed. For others, like hard drives, firmware can be updated. When Seagate released an updated
16 firmware version for the ST3000DM001, it would be programed into Drives that during the
17 manufacturing process. Seagate would also make the firmware update available for download by
18 ST3000DM001 consumers.⁶¹

19 157. The ST3000DM001 underwent at least 12 firmware updates as shown in
20 FED_SEAG0018735, a spreadsheet that lists Seagate’s firmware releases. The last update referenced
21 on this spreadsheet was from March 2015 and, as such, I do not know whether any subsequent
22 firmware versions were released.

23 158. For a high-volume product that had supposedly gone through a plethora of pre-release
24 qualifying tests, this is an extraordinarily high number of versions, and strongly suggests that either
25
26

27 ⁶¹ See Seagate, Barracuda (1TB/disk platform) Firmware Update, [http://knowledge.seagate.com](http://knowledge.seagate.com/articles/en_US/FAQ/223651en)
28 /articles/en_US/FAQ/223651en (last accessed Oct. 9, 2017).

1 the firmware was unstable, or the firmware was being called upon to solve other problems in
2 hardware, or both.

3 159. For example, according to an internal Seagate email, the ST3000DM001 suffered
4 from a “firmware bug that affected reliability” by putting it in a Drive Not Ready (DNR) state.⁶² The
5 bug was purportedly fixed in April 2012.

6 160. Seagate’s support page devoted to firmware updates includes the following
7 statement:⁶³

8 Like any software, firmware is improved over time and problems are
9 also fixed. Many drive families have **a couple of firmware releases**
during the life of the product. [Emphasis added]

10 161. The statement that many drive families have a couple of firmware releases during the
11 life of the product comports with my experience of high volume products whereby there will be an
12 initial firmware release and then perhaps one or two more during the life of the product.⁶⁴

13 162. However, as discussed above, the ST3000DM001 went through at least twelve
14 firmware versions during its product life, which supports the hypothesis that ST3000DM001 was an
15 abnormally unstable product. The abnormality is further evidenced by the reaction of Glen Almgren,
16 Seagate’s Reliability Engineering Director, during his deposition in which he stated it would surprise
17 him to learn that the Drive had 10 or more post-production firmware releases.⁶⁵

18 163. The documents embedded in the spreadsheet listing firmware releases provide an
19 understanding of the Drive’s various firmware problems. Note that because these documents were
20 embedded, they are not separately Bates stamped.

21 164. The first embedded document pertains to a firmware update that was released on
22 January 11, 2012. The problem addressed by the update was that Seagate firmware engineers

23
24 ⁶² FED_SEAG0009894, at 9895.

25 ⁶³ Seagate, *Firmware Updates for Seagate Products*, http://knowledge.seagate.com/articles/en_US/FAQ/207931en (last accessed Oct. 9, 2017).

26 ⁶⁴ The support page also states, “Please note that Seagate does not offer details about specific
27 firmware.” This level of concealment is unusual as most companies (including Western Digital)
provide information concerning firmware updates.

28 ⁶⁵ See Almgren Dep. 61:5-62:5.

1 neglected to set a debug serial port on the hard drive to a fixed state. This made the hard drive
2 susceptible to erroneously executing commands that it perceived to be valid but were just electrical
3 noise on the debug serial port. The effects of this could be serious -- it could result in the Drive going
4 to a Drive Not Ready (DNR) state. This means the drive would appear as being 'not ready' – and
5 thus would not be accessible.

6 165. The solution to the problem was trivial – Seagate engineers simply had to set a bit in a
7 control register on the disk drive to fix the diagnostic port into a fixed state, rather than allow it to
8 float in an unstable manner.

9 166. The consequences of failing to set a debug serial port to a fixed state are well known
10 in the hard drive industry, and in my opinion, Seagate had at least four opportunities to prevent or
11 detect this problem pre-release: At the schematic review stage, at the debug serial port protocol
12 design stage, at the firmware code review stage, and at the testing stage. The fact that such a
13 potentially serious problem with such a simple fix was not addressed until months after the
14 ST3000DM001 had been released into mass production supports the notion that the Drive was not
15 adequately tested prior to shipment to end users.

16 167. By way of further example, there was yet another firmware update on April 23, 2012,
17 approximately three months after the first update.

18 168. This firmware update was intended to, among other things, address a “race condition”
19 and “erroneous drive cache hits.” A race condition is normally a serious defect that could result in
20 the drive malfunctioning. An erroneous drive cache hit is also a serious error and could result in
21 incorrect data being provided to the user. The fact that these problems were not addressed until a
22 year after the Drive was first released further indicates that the ST3000DM001 was not adequately
23 tested prior to shipment.

d. **The Drive was Subject to Repeated Shipping Holds, and the SBS and Distribution Channels were Dumping Grounds for Bad Drives**

169. Given the instability of the ST3000DM001, it is not surprising that the Drive was subject to repeated shipping holds. The numerous ship hold documents produced by Seagate during discovery show the extent of the reliability problems with the Drive.⁶⁶

170. The Drive was subject to at least 13 ship holds between June 2011 and August 2012 alone. This number of ship holds in such a short amount of time is staggering. In my experience, a ship hold every month on average for over a year indicates a product with ongoing problems.

171. At least four of the ship holds involved head-related failures,⁶⁷ and these ship holds affected a massive number of drives. For example, a ship hold order put in place on February 4, 2012 affected 320,025 Drives that had already been shipped from one of Seagate's factories in Korat, Thailand.⁶⁸

172. In addition, a March 15, 2012 ship hold affected approximately 85,000 shipped drives.⁶⁹ Of particular importance is that this ship hold only applied to OEM Drives, and the factory was instructed to **"Downgrade failed drives to Disty and SBS."**⁷⁰ In other words, Seagate shipped failed OEM Drives to hard drive retailers and resellers, who in turn sold them to consumers.

173. Furthermore, some of the ship holds describe contamination issues. An internal Seagate email sent on July 12, 2012 stated that **"Grenada triggers are mainly due to head instability and particle related issues."**⁷¹ The term "particle related issues" is a euphemism for contamination. The email continues:

We identified **head instability issue** with the first SSO [Stop Ship Order] in dec/jan. **As a company we made a decision to use the**

⁶⁶ E.g. FED_SEAG0006184; FED_SEAG0008927; FED_SEAG0016862; FED_SEAG0054864; FED_SEAG0054917; FED_SEAG0054972; FED_SEAG0054997; FED_SEAG0055000; FED_SEAG0055022; FED_SEAG0055026; FED_SEAG0055041; FED_SEAG0055073; FED_SEAG0055087; FED_SEAG0055139; FED_SEAG0055154.

⁶⁷ See FED_SEAG0054997; FED_SEAG0055041; FED_SEAG0055073; FED_SEAG0055087.

⁶⁸ FED_SEAG0054972, at 54974.

⁶⁹ FED_SEAG0055041, at 55044.

⁷⁰ FED_SEAG0055041, at 55044.

⁷¹ FED_SEAG0060976.

‘bad’ wafer/slider material to meet Q3/Q4 volumes. We expected to finish using this material in middle of Q4, however we will continue to consume until WW17 (via disty/SBS config). To improve OEM performance we are using non-SLT-05 for OEMs...To further improve OEM performance we have tighter OEM cert specs. **I suspect this is another reason why OEM performance in QRT is improving but Disty is not** (even with non-SLT05 material).⁷²

174. This passage is extremely important for two reasons. First, it further demonstrates Seagate’s willingness to dump bad Drives into the “disty” and SBS channels, and it makes it clear that Seagate did so to meet production volumes. Second, it shows that Seagate prioritized the OEM channel such that it was willing to tighten OEM certification specifications when problems arose but did not do the same for the other channels, resulting in a deleterious impact on the reliability of the Drives shipped to SBS and distribution consumers.

175. There are additional examples of bad Drives being sent to the distribution and SBS channels. On at least one occasion, an OEM customer placed a ship hold on the ST3000DM001 because of the defect rates found in production. Despite this, Seagate continued to ship Drives to the other channels the include the consumer making up this class. This is summarized in Figure 24, below, which shows that in May 2012, [REDACTED]

[REDACTED] Despite this, there is no indication that Seagate halted shipment to the other channels. In effect, Seagate lowered their inventory and kept production levels high by redirecting drives refused by their OEMs into the SBS and “disty” channels bound for consumers making up this class. Without high production levels, Seagate would certainly be at a disadvantage to its major competitor, Western Digital.

Figure 24: [REDACTED]

⁷² *Id.*

e. **Reliability Problems Escalated Rapidly after Release of the ST3000DM001**

176. The ship holds, as well as other documents produced by Seagate during discovery, indicate that the ST3000DM001 was unreliable, unstable, and defective, and that problems with the Drive began to manifest shortly after its release and escalated in early 2012. The figures below are from February 2012. Note that the dates shown in the charts (e.g. 1218) refer to week 18 in financial year 2012. Figure 25 shows that Grenada's projected AFR was 2.21% and that its failure percentages were constantly above the warning levels. The main factors driving the elevated failure rate included "degraded heads," "head instability," and "NMD" (new media defect) caused by contamination. Disk drive heads are very sensitive devices that fly over the disk media so closely that a human hair would cause them to crash. Heads degrade when subject to abrasion from contacting the disk, sometimes damaging the media as well. A head that collects contaminants or excessive lubricant on its air bearing surface will fly higher and generate more heat due to increased friction. The combination of increased flying height and increased Johnson noise, proportional to temperature, leads to new defects when writing data and reading back from the disk. In the worst case, the areas of the disk with heavy contaminants may trigger new media defects that are added to the defect list after the disk leaves the manufacturing facility.

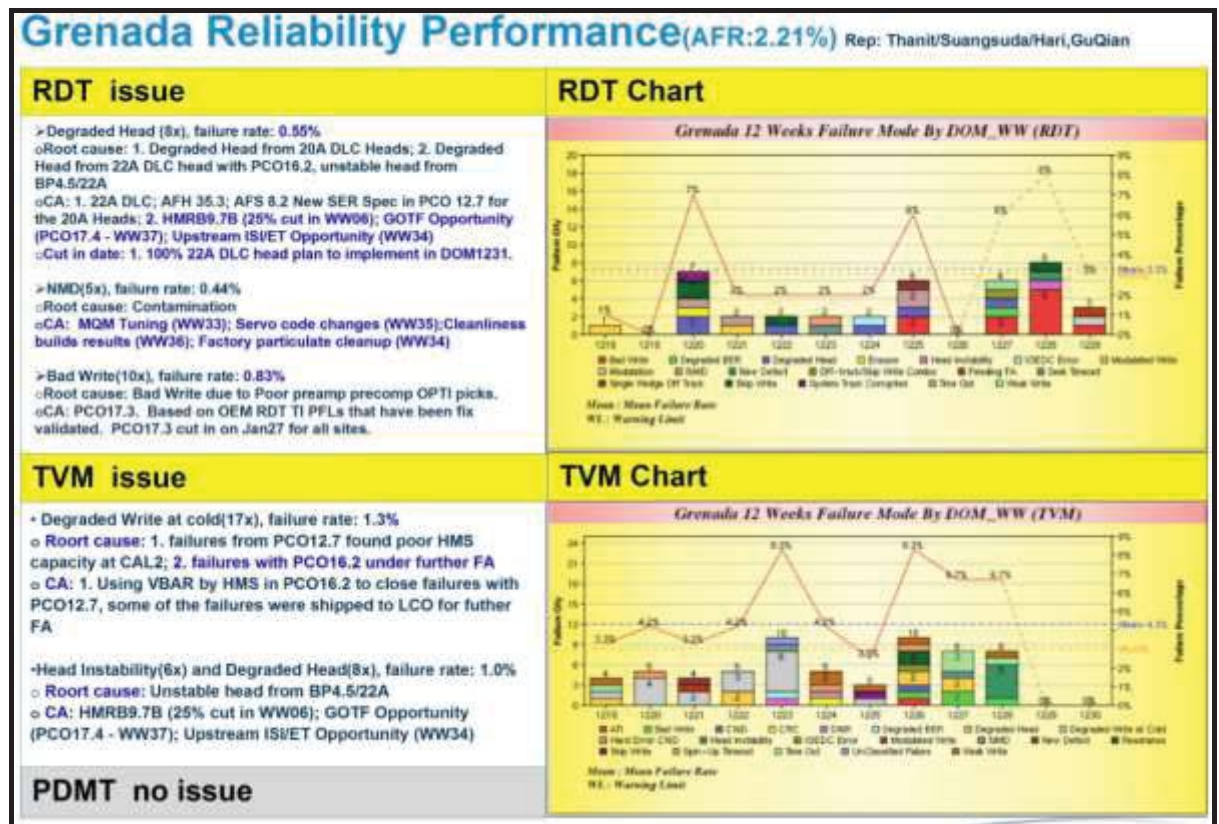


Figure 25: FED_SEAG0009670, at 9678

177. Figure 26, below, shows in dramatic fashion that not only were the problems bad – but they were getting steadily worse. The green line at 0.5% represents Seagate’s target. The orange line at 1% AFR is marked as “UCL” or Upper Control Limit. It can be seen that the actual projected AFR based on ORT (Ongoing Reliability Testing) is above 1% for 12 weeks straight and is rapidly increasing at the end of the period.

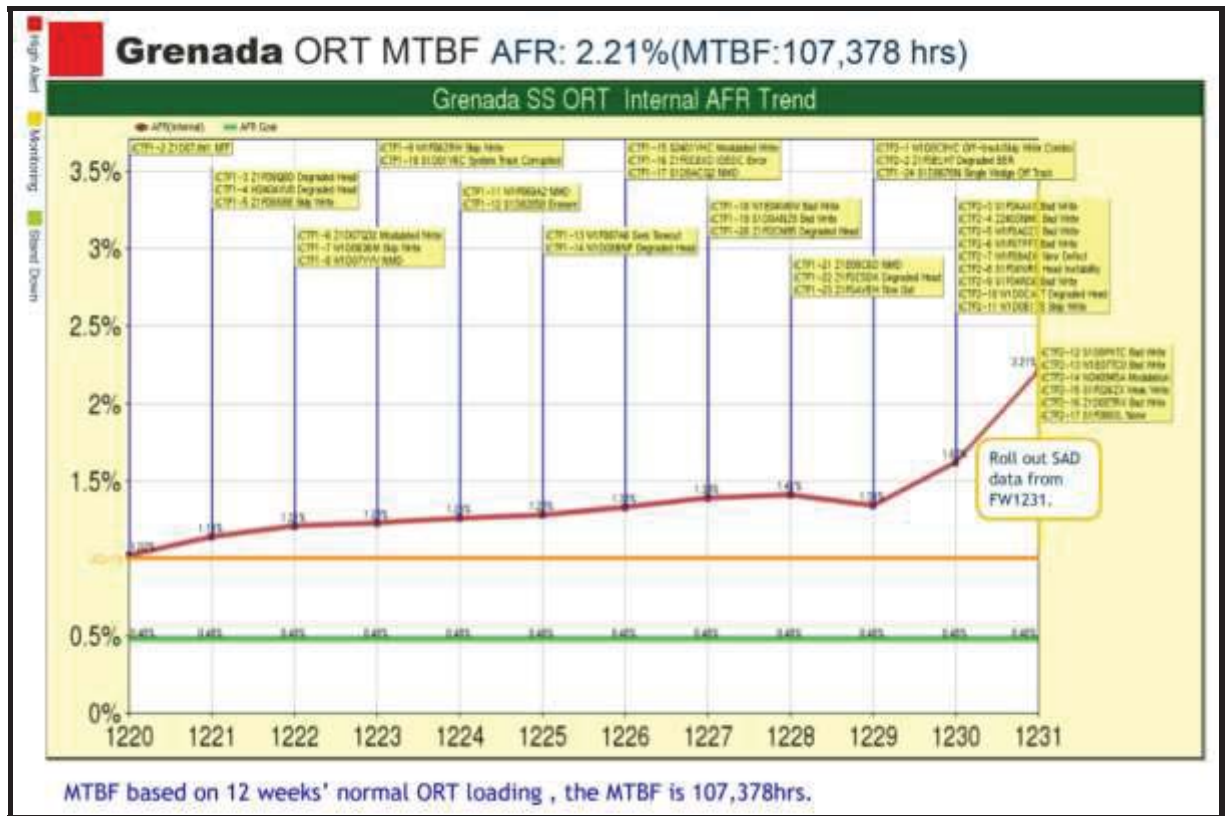


Figure 26: FED_SEAG0009670, at 9681

178. Figure 27, below, provides an analysis using RDT (Reliability Demonstration Testing). It extends a few weeks more into 2012 work week 34 and shows that work week 33 was the worst week yet.

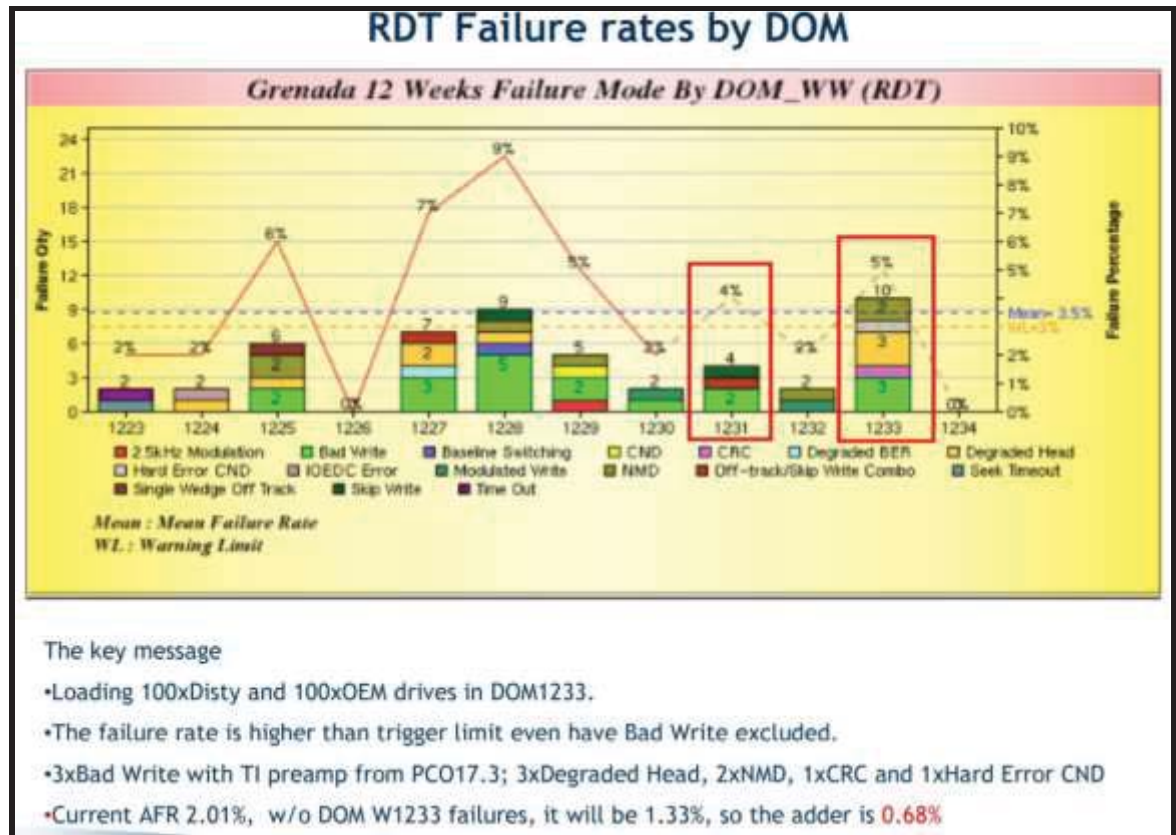


Figure 27: FED_SEAG0009576, at 9580

179. As set forth in Section G above, on June 4, 2012, ORT revealed that Grenada Classic exhibited a 3.436% AFR that is not <1%.

Grenada ORT FE Table			
Grenada Classic ORT			Updated: 6-4-12 12:00 AM
AFR (1st year Weibull)	3.436%	From all fails Weibull MLE	No_Info QTY_TESTED
MTBF (1st year Weibull)	68645.4		
Minimum AFR:	0.021%	From zero fail Weibull @ 50% CL	2400 POH/Year
Total Number of Failures	81		0.506781 Weibull Beta
AFR for 1 failure	0.042%	AFR decrease per failure @ 100% fix effectiveness	535 Average Test Hours

*Figure 28: Grenada Classic ORT raw AFR was 3.436% on 6/4/2012
(FED_SEAG0026751, at 26785)*

180. Even with the contemplated fix effectiveness calculated, the projected AFR was reduced to only 2.35%, and still not <1% as shown by Figure 29, below.

SPPL-61 GMD Due to Inefficient Paddling - Post SAD	PCO17.7C - Structural Paddling Change PCO17.8 to include AFMD.0TA Scan under Serial change		1	0.042%	40%	40%	3.48%	3.48%	PFL-08294
SPPL-64 NMD due to loose PZT			1	0.042%	0%	0%	0.43%	0.43%	PFL-080799
SPPL-68 BHz Modulation due to			1	0.042%	0%	0%	0.43%	0.43%	PFL-0840549
SPPL-69 GMD Due to incomplete			1	0.042%	0%	0%	0.43%	0.43%	PFL-410763
SPPL-115 Bad Write from T1Pwamp with Pre PCO17.7C	T1Pwamp Bad Write mitigation Opt 18.5 changes in PCO17.7C, not in VV042	PCO17.7C lines validated on 22 previous bad write failures in LCO	1	0.042%	95%	95%	3.38%	3.38%	PFL-4187008
SPPL-172 Aborted Write due to Power Reset - Test Equipment Related			1	0.042%	100%	100%	3.39%	3.39%	PFL-4263026
SPPL-173 unqualified material escaped to mass production			1	0.042%	0%	100%	0.43%	3.39%	PFL-4329022
Total Number of Fails			81	Reduced AFR:		2.35%	1.79%		
				Corresponding MTBF:		100K	132K		

**Figure 29: Grenada Classic ORT Reduced AFR was 2.35% on 6/4/2012.
(FED_SEAG0026751, at 26786)**

**f. Internal Seagate Documents Explicitly Acknowledge that the
ST3000DM001 was Unstable, Unreliable, and Defective**

181. The ST3000DM001's problems and excessive failure rate continued beyond 2012.

182. One of the most significant issues was an Apple recall of the Drive and the underlying contamination failures that led to it.

183. An internal Seagate document, dated March 2015, stated:

184. [REDACTED]

185. The Yearly Return Rate ("YRR," also referred to as "Annual Return Rate," or "ARR") represents all of the drives returned to Seagate for any reason. Hard drive manufacturers, including Seagate, analyze returned drives and categorize them. For example, a large percentage will

⁷³ FED_SEAG0057214, at 57215.

⁷⁴ FED_SEAG0002673, 2674.

1 be accepted as genuine failures, others will be classified as failed due to abuse, while others will be
 2 classified as No Trouble Found (NTF), meaning the drive appears to be working perfectly. It is worth
 3 noting that drives that experience transient problems (such as the DNR problem caused by a
 4 firmware error described in Section iii, above) would be classified as NTF by Seagate unless the
 5 transient problem with the floating serial debug port appeared during their failure analysis.

6 186. The YRR is a reliability metric in that a high YRR is indicative of an unreliable,
 7 unstable hard drive. [REDACTED]

8 [REDACTED]
 9 187. At this time, a root cause of the high return rate was contamination that occurred
 10 during the manufacturing process.⁷⁵ Specifically, the contamination was “PFPE smear on media and
 11 contamination on ABS.”⁷⁶ “PFPE” stands for PerFluoroPolyEther, which is a type of lubricant and
 12 “ABS” stands for air bearing surface – that section of the head closest to the platter that is shaped to
 13 allow the head to fly over the platter at a prescribed flying height. PFPE is a common lubricant in the
 14 disk drive industry. When used properly, it forms an even coating across the disk. However,
 15 contaminants in the PFPE cause small mounds to form that strike the air bearing surface and can
 16 result in PFPE being smearing in a non-uniform way across the disk. In the worst case, some areas of
 17 the disk are left without lubricant and become defective, while others have some much piled up the
 18 head cannot fly over them safely.

19 188. Seagate knew about the contamination issue as early as 2013, [REDACTED]
 20 [REDACTED]
 21 [REDACTED]
 22 [REDACTED]

23 189. The Apple recall was announced on June 19, 2015, but the announcement did not
 24 contain any reference to Seagate.⁷⁸

25 ⁷⁵ FED_SEAG0057214, at 57215; FED_SEAG0057123, 57127.

26 ⁷⁶ FED_SEAG0057214, at 57215.

27 ⁷⁷ See FED_SEAG0057214, at 57215.

28 ⁷⁸ FED_SEAG0002673, 2675.

190. In addition to the 130,000 affected OEM Drives sold to Apple, Seagate projected that there were “**850K [non-OEM] drives still in warranty that may be returned due to contamination issue.**”⁷⁹

191. The severity of this issue is best illustrated by the fact that, internally, Seagate considered offering free data recovery to customers who called and complained about affected ST3000DM001 Drives that had failed, at a projected cost of \$26.8 to \$148.9 million.⁸⁰ Figure 30 below is a chart produced by Seagate during the course of discovery.

PRELIM Worst-Case Scenario			
	Apple Recall	Channel	TOTAL
Affected Quantity	135,000	850,000	985,000
Expected Returns (including 100% of all products)	135,000	850,000	985,000
Costs:			
Cloud Backup Services For 1 Year @ \$2/month for 200GB	\$ 3,240,000	N/A	\$ 3,240,000
Data Recovery @ \$340/drive (including 50% of channel customers)	N/A	\$ 144,500,000	\$ 144,500,000
Solutions Center cost for add'l temp HC over 6 months @ ~\$5/drive		\$ 4,444,444	\$ 4,444,444
TOTAL COST	\$ 3,240,000	\$ 148,944,444	\$ 152,184,444
Grenada 3TB Product "Contamination" Issue			
PRELIM Expected Scenario (based on Moose epidemic failure rates)			
	Apple Recall	Channel	TOTAL
Affected Quantity	135,000	850,000	985,000
Expected Returns (including 50% of Apple customers and 18% of product from channel)	67,500	153,000	220,500
Costs:			
Cloud Backup Services For 1 Year @ \$2/month for 200GB	\$ 1,620,000	N/A	\$ 1,620,000
Data Recovery @ \$340/drive (including 50% of channel customers would request data recovery)		\$ 26,010,000	\$ 26,010,000
Solutions Center cost for add'l temp HC over 6 months @ ~\$5/drive		\$ 800,000	\$ 800,000
TOTAL COST	\$ 1,620,000	\$ 26,810,000	\$ 28,430,000

Figure 30: Seagate's Internal Analysis of Projected Cost Associated with the Contamination Defect (FED_SEAG0055783)

192. Despite the severity and massive scale of the problem, Seagate never followed through on its plan to offer free data recovery to consumers, nor did it issue any sort of consumer

⁷⁹ FED_SEAG0055784, at 55785.

⁸⁰ Clark Dep., at 136:1-13.

1 product recall.⁸¹ In fact, there is no indication that Seagate *ever* informed consumers that there was a
 2 contamination problem with the Drive.⁸² Seagate has not issued a product recall since at least 2001.

3 193. There are numerous other internal Seagate documents and emails which explicitly
 4 evidence that Seagate knew the Drive was riddled with issues. Indeed, as early as October 10, 2012,
 5 Seagate was aware that the Grenada was plagued with “NHK particulate contamination” and “head
 6 instability” issues.⁸³

7 194. In summary, internal Seagate documents, including those pertaining to the Apple
 8 recall, show that the ST3000DM001 was unstable, defective, and suffered from contamination issues
 9 on a massive scale. They further demonstrate that Seagate was aware of these issues and concealed
 10 them from Apple, retailers, and end-users. Contamination-related issues and failures, as well as head-
 11 related failures, were also the subject of multiple ship holds and documents pertaining to the
 12 degrading reliability of the Drive, and Seagate “addressed” the problem by dumping bad OEM
 13 Drives into the SBS and distribution channels. These same Drives were ultimately sold to
 14 consumers.

15 195. The instability, unreliability, and defective nature of the Drive is further exemplified
 16 by the Drive’s extremely low factory yield; the large number of engineering changes made to the
 17 Drive, particularly post-release; the high percentage of engineering changes that were temporary,

18 ⁸¹ Clark Dep., at 89:10-15, 120:12-121:12.

19 ⁸² Seagate has seen high return rates on the Drive in other instances. For example, an internal
 20 Seagate document dated July 25, 2014 states that the Field Annual Return Rate for the BackUp Plus
 21 Desk was 9.14%. *See* FED_SEAG0026135, at 26138. Likewise, it states that the Field ARR for the
 22 Expansion Plus and the Expansion Plus Desk were 7.63% and 12.15%, respectively. *See id.* at
 26139. Seagate never issued a recall for these Drives. In fact, since at least 2001, Seagate has not
 issued a recall for any hard drive. *See* Clark Dep. at 89:10-15.

23 ⁸³ FED_SEAG0056259, at 56296 (“DSP tolerance to MBA” is also listed, which is also
 24 addressed in this report). In a January 26, 2015 email, Dave Rollings, Field Applications Engineer,
 25 enumerated a multitude of problems with Grenada. Specifically, he stated that the Drives
 26 manufactured in 2012 had a “2x field return rate” due to “a multitude of issues” related to particle
 contamination, air bearing design problems, and other issues that needed to be fixed with subsequent
 firmware releases. FED_SEAG0009883, at 9885.

27 In a May 20, 2015 email, Joni Clark, Global NAS Segment Manager, stated that the Backblaze
 28 reports were “not baseless” and that the ST3000DM001 drives “did have contamination issues that
 caused them to fail much faster and more.” FED_SEAG0006071, at 6072.

indicating that Seagate was attempting to devise quick fixes for the Drive; the staggering number of ship holds put in place; and the abnormally high number of firmware revisions.

196. The foregoing also demonstrates that Seagate's reliability testing and quality control processes were inadequate and flawed and that the Drive was released before it was ready for production. This is further exemplified by the fact that Seagate made at least one significant design change and at least one substantial manufacturing process change mere weeks before the Drive was released; engineering changes were made to the Drive post-release that should have been done pre-release. Furthermore, Seagate redesigned a major Drive component a mere four months after the Drive's release; and Seagate failed to detect a major problem with the Drive's disk separator plate for two years.

J. Given Its Knowledge that the Drive Was Unstable and Unreliable, Seagate Gradually Changed the Specifications

197. Seagate has made significant changes to various specified parameters between 2011 and 2017. The table below summarizes some of the more significant changes taken from various versions of the ST3000DM001 Product Manual.

	<i>Rev A2</i> ⁸⁴	<i>Rev G</i> ⁸⁵	<i>Rev P</i> ⁸⁶	<i>Rev. V</i> ⁸⁷
<i>Max ambient temperature (°C)</i>	70	60	60	NS ⁸⁸
<i>Maximum case temperature (°C)</i>	69	69	69	60
<i>Maximum operating wet bulb temperature (°C)</i>	37.7	37.7	37.7	26
<i>Maximum non-</i>	40	40	40	29

⁸⁴ FED_SEAG0019045. Dated April 2011.

⁸⁵ FED_SEAG0030657. Dated October 2012.

⁸⁶ FED_SEAG0003639. Dated September 2015

⁸⁷ Dated September 2016. This is the latest version of the manual available on Seagate's website at <http://www.seagate.com/www-content/product-content/barracuda-fam/desktop-hdd/barracuda-7200-14/en-us/docs/100686584v.pdf>

⁸⁸ NS = Not Specified

	<i>Rev A2⁸⁴</i>	<i>Rev G⁸⁵</i>	<i>Rev P⁸⁶</i>	<i>Rev. V⁸⁷</i>
<i>operating wet bulb temperature (°C)</i>				
<i>AFR (%)</i>	0.34	NS	<1.0	< 1.0
<i>Workload (TB / year)</i>	NS	< 55	< 55	< 55
<i>Power On Hours</i>	2400	8760	2400	2400
<i>Storage (original unopened package) max days</i>	NS	NS	NS	180
<i>Storage unpackaged max days</i>	NS	NS	90 at wet bulb of 32°C	60 at wet bulb of 26°C

Figure 31: Change in specification of ST3000DM001

198. Figure 31 shows some key ST3000DM001 specifications taken from the Product Manual dated April 2011, October 2012, September 2015 and finally September 2016. Text highlighted in red shows a parameter that was made more restrictive when compared to the column to the left. Green indicates a specification that was made more permissive. It may be seen that over the span of 5.5 years Seagate has successively derated their specification and made the operating envelope more restrictive. From a reliability perspective the key changes are discussed below:

1. Maximum Case Temperature

199. Seagate reduced the maximum case temperature from 69°C to 60°C. This is a very large reduction and is particularly notable in that as recently as September 2015 (i.e. four and a half years after the product was released), the maximum allowed case temperature was specified at 69°C. The fact that Seagate saw fit to reduce this temperature by 9°C strongly suggests that the previous value of 69°C was having a deleterious impact on system reliability. To understand how onerous this restriction is, it is important to understand how much hotter the ST3000DM001's case is than the ambient temperature. Testing performed in 2011 showed that the ST3000DM001 case temperature was 38°C above ambient, where the ambient temperature was 40°C and the HDD temperature

1 stabilized at 78°C.⁸⁹ If this data is still valid, then this implies that with a maximum allowed case
 2 temperature of 60°C, the actual ambient temperature around the disk drive should not exceed 60°C -
 3 38°C = 22°C (i.e. 72°F). Given that it is inevitably warmer inside a computer than inside a room
 4 (5°C would be a conservative estimate), it suggests that the maximum room temperature in which an
 5 ST3000DM001 should be used is $60 - 38 - 5 = 17^{\circ}\text{C}$ (63°F). This is a remarkably low temperature.
 6 Any customer running an ST3000DM001 in a room hotter than 17°C would thus expect to see an
 7 increased AFR.

8 **2. Maximum Operating Wet Bulb Temperature**

9
 10 200. The maximum operating wet bulb temperature has been reduced from 37.7°C to
 11 26°C. This is a very large reduction and is particularly notable in that as recently as September 2015
 12 (i.e. four and a half years after the product was released), the maximum allowed operating wet bulb
 13 temperature was 37.7°C. The fact that Seagate saw fit to reduce this temperature by 11.7°C strongly
 14 suggests that the previous value of 37.7°C was having a deleterious impact on system reliability. To
 15 understand how onerous this restriction is, an ambient temperature of 83°F at a relative humidity of
 16 75% would be at the wet bulb temperature limit of 78.8°F or 26°C. To put this in perspective, at the
 17 time of writing this report, it is 81°F and 84% relative humidity in Houston, Texas. This has a wet
 18 bulb temperature higher than permitted by Seagate's latest specification.

19 **3. Unpackaged Storage Specification**

20 201. The unpackaged storage specification has become progressively more onerous. In
 21 2011 and 2012 there were no restrictions specified. By 2015 the drive could be stored for 90 days
 22 provided the environmental specifications including a 32°C wet bulb limit was met. Finally, in 2016,
 23 the storage specification was reduced to 60 days provided the environmental specification including
 24 a 26°C wet bulb limit was met. Again, drives shipped to retail outlets in Houston, such as BestBuy or
 25 Costco, could remain in a warehouse for 60 days and be exposed to temperature and humidity
 26 outside of Seagates derated specifications, before being purchased by an unknowing consumer.

27
 28 ⁸⁹ See FED_SEAG0009095 at 9100, 9102.

4. Workload Rating

202. By Revision G (October 2012) a revised rated workload statement had been added to the user manual, which stated:

Average rate of <55TB/year. The MTBF specification for the drive assumes the I/O workload does not exceed the average annualized workload rate limit of 55TB/year. Workloads exceeding the annualized rate may degrade the drive MTBF and impact product reliability. The average annualized workload rate limit is in units of TB per year, or TB per 8760 power-on hours. Workload rate limit= TB transferred x (8760/recorded power-on hours).⁹⁰

203. The statement is a masterpiece in obfuscation. In fact, Seagate acknowledged in an internal document that “Seagate does a poor job in defining the product usage conditions and AFR transfer functions (guidelines) in our product manual compared to Hitachi.”⁹¹

204. Nonetheless, I interpreted the above language to mean that a user should not exceed 55TB in a year, where a year is 8760 POHs. There is nothing in this statement (or any other statement in the manual) to suggest that the AFR specification is based on 2400 POH. Indeed, the number 2400 does not appear in the Rev. G manual, nor does any actual statement of what constitutes the specified MTBF or AFR.

205. This is significant, because, higher workload stress has an impact on hard drive reliability. Indeed, Dr. Khurshudov, in the June 1, 2012 version of his report, concluded, “There seems to be a good correlation between the amount of workload stress and the product propensity to show constant failure rate or wearout.”⁹² I agree with Dr. Khurshudov on this point because it is consistent with his opinion that the Weibull β values should be changed to reflect constant failure or wearout.

206. A drive that is powered down has no stress, and Seagate is now defining a workload of 55TB/year, which is less than 2MB/second of user data transfer. For comparison, the Seagate

⁹⁰ FED_SEAG0030657, at 30668. The same, or a substantially similar, statement remained in various iterations of the Product Manual until January 2015, when the POH rating was downgraded to 2400.

⁹¹ FED_SEAG0056341, at 56346.

⁹² FED_SEAG0001986, at 1993.

1 ST3000DM001 drives support the SATA 6Gbit/second transfer rate, which is capable of transferring
2 94MB/second. This nearly 50x derating of transfer workload, from 94MB/second to 2MB/second is
3 unheard of in the data storage industry. I do note that most cell phone plans now limit the amount of
4 data transferred per month, and cloud storage providers charge for monthly data transfers, but I have
5 never heard of a limit placed on data transfers from a customer owned storage device.

6 **K. Seagate Knew that the Drive Was Not Suitable for RAID**

7 207. Seagate advertised the ST3000DM001 as being suitable for use in RAID, and the
8 performance of the 7200 RPM Drive would be attractive for desktop RAID. However, unreliable
9 drives are not suitable for use in RAID. As discussed throughout this report, the ST3000DM001 not
10 only had a higher AFR than advertised, but it was also unstable for desktop RAID. The
11 ST3000DM001 required numerous engineering changes and firmware updates to address a multitude
12 of serious problems in the design and manufacture of the Drive.

13 208. A RAID is a collection of hard drives placed in an enclosure with a RAID controller
14 that enhances reliability and availability of user data. There are different “levels” of RAID, including
15 RAID-0, RAID-1, RAID-5, RAID-6, and RAID-10. All of these configurations provide data
16 redundancy (except RAID-0, which is used for increasing storage space and improving
17 performance). This means that the same data is written to multiple hard drives such that if one drive
18 fails, the RAID can “rebuild” the data and preserved it. However, partial or total data loss can occur
19 if another hard drive fails during the rebuilding process, which is often lengthy.

20 209. Accordingly, unreliable, unstable drives are not suitable for use in RAID because they
21 substantially increase the probability of a failure occurring during a rebuild vis-à-vis more reliable,
22 stable hard drives. Since Seagate knew that the ST3000DM001 was unreliable and unstable, it also
23 knew that the Drives were not fit for use in RAID.

24 210. Moreover, RAID-1, which uses two hard drives that mirror data, and RAID-5, which
25 uses three or more hard drives, are most common home RAID configurations. Seagate admitted in a
26

1 December 2012 email to a customer that the ST3000DM001 is not designed for RAID-5 and that if it
2 is used in that configuration, “you can expect to deal with RAID failures.”⁹³

3 211. Other internal Seagate documents further show that Seagate knew that the
4 ST3000DM001 was not suitable for RAID and that it should not have been advertised as such. For
5 example, an internal Seagate email from January 2014 states that “the main issue here is that these
6 guys are using Desktop drives in RAID systems . . . desktop drives like ST3000DM001 (Grenada) . .
7 . *are not designed for this type of environment.*”⁹⁴ (Emphasis added). Another internal Seagate email
8 from March 2016 states, “As a suggestion, if we do not want DT [desktop drives] to be used to [sic]
9 a wrong environment, we should specify that the DT product is for 2400 application on the manual,
10 do not recommend for RAID environment.”⁹⁵ Other internal Seagate documents and emails also
11 discuss how the ST3000DM001 should not be advertised as “perfect” for or otherwise suitable for
12 RAID.⁹⁶

13 212. Seagate did not design the ST3000DM001 to be suitable for use in a RAID
14 environment due to the Drive’s instability and unreliability. Since Seagate was the entity that
15 designed and tested the Drive, it by necessity knew, at the time of Drive release at the latest, that the
16 ST3000DM001 was not suitable for use in RAID. Seagate went so far as informing a customer that
17 the Drive was not suitable for RAID, but failed to inform consumers of such issues, or problems with
18 contamination, or issue any recalls that may have prevented consumers in this class from losing their
19 data.

20 V. SUPPLEMENTATION OF OPINIONS

21 213. I reserve the right to adjust or supplement my opinion after I have had the opportunity
22 to review other deposition testimony or in light of additional documents or other discovery that may
23 be brought to my attention. I also reserve the right to adjust or supplement my analysis in light of
24

25 ⁹³ FED_SEAG0054829, at 54830.

26 ⁹⁴ FED_SEAG0006420.

27 ⁹⁵ FED_SEAG0021938, at 21939.

28 ⁹⁶ See FED_SEAG55589; FED_SEAG0021998; FED_SEAG0007293, at 7299.

1 any critiques of comments on my report and to offer additional opinions and evidence in reply to any
2 opinions advanced by or on behalf of defendant Seagate.

3 I declare under penalty of perjury under the laws of the United States that the foregoing is
4 true and correct. Executed this 07th day of November 2017, at Santa Cruz, California, USA.

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Andrew Hospodor, Ph.D

APPENDIX 1

MATERIALS RELIED UPON OR CONSIDERED

Pleadings, Discovery Responses, and Deposition Transcripts:

In re: Seagate Technology LLC Litigation, Second Consolidated Amended Complaint.

In re: Seagate Technology LLC Litigation, Seagate Technology, LLC's Second Amended Response to Interrogatory Nos. 9 and 10 of Plaintiffs' First Set of Interrogatories.

July 26, 2017 Deposition of Seagate 30(b)(6) Designee Glen Almgren.

September 7, 2017 Deposition of Seagate 30(b)(6) Designee Patrick Dewey.

September 8, 2017 Deposition of Andrei Khurshudov.

October 20, 2017 September 7, 2017 Deposition of Seagate 30(b)(6) Designee Alan Clark

Websites and Documents Obtained from the Internet:

Seagate, Hard disk drive reliability and MTBF / AFR

http://knowledge.seagate.com/articles/en_US/FAQ/174791en?language=en_US&key=ka030000000tmWGAAY&kb=n&wwwlocale=en-us (last accessed October 10, 2017).

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Seagate, *Desktop Hard Drives*,

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Seagate, *July 2012 Storage Solutions Guide*, available at https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solutions-guide-sg1351-11-1210us.pdf.

1 Seagate, *October 2013 Storage Solutions Guide*, available at [https://www.seagate.com/files/www-](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-1310us.pdf)
2 [content/product-content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-1310us.pdf)
3 [1310us.pdf](https://www.seagate.com/files/www-content/product-content/_cross-product/en-us/docs/storage-solution-guide-oct-13-ssg1351-14-1310us.pdf).

4 Seagate, *September 2016 Storage Solutions Guide*, available at [http://www.seagate.com/www-](http://www.seagate.com/www-content/product-content/barracuda-fam/desktop-hdd/barracuda-7200-14/en-us/docs/100686584v.pdf)
5 [content/product-content/barracuda-fam/desktop-hdd/barracuda-7200-14/en-us/docs/100686584v.pdf](http://www.seagate.com/www-content/product-content/barracuda-fam/desktop-hdd/barracuda-7200-14/en-us/docs/100686584v.pdf)

6 Seagate, *Hard disk drive reliability and MTBF / AFR*,
7 [http://knowledge.seagate.com/articles/en_US/FAQ/174791en?language=en_US&key=ka030000000t](http://knowledge.seagate.com/articles/en_US/FAQ/174791en?language=en_US&key=ka030000000tmWGAAY&kb=n&wwwlocale=en-us)
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12 http://knowledge.seagate.com/articles/en_US/FAQ/207931en.

13 Western Digital, *How drive reliability is measured and the MTBF of WD drives*,
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21 MjM Data Recovery Ltd., *Head Stack Assembly*, [https://www.mjmm.co.uk/hard-disk-](https://www.mjmm.co.uk/hard-disk-disassembly/hard-disk-head-stack.html)
22 [disassembly/hard-disk-head-stack.html](https://www.mjmm.co.uk/hard-disk-disassembly/hard-disk-head-stack.html).

23 **Documents produced during discovery (beginning Bates numbers):**

24 *See Exhibit A to Appendix I.*

APPENDIX 2

Andrew David Hospodor, Ph.D.

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408.921.5099 andy.hospodor@ieee.org

An accomplished executive, engineer-scientist experienced in both startups and Fortune 500 companies having extensive background in distributed systems, applications and storage. Strengths include industrial-academic relationship building, intellectual property development, Inter Parte Review, Source Code Inspection, data forensics, industrial espionage, strategic planning and technical leadership,

Education:

- **Ph.D. Computer Engineering, Santa Clara University, Santa Clara, CA, 1994**

Emphasis on storage architecture and embedded systems. Minor in business administration.

Dissertation: A Study of Prefetch in Caching SCSI Disk Drive Buffers.

- **M.S. Computer Science, Santa Clara University, Santa Clara, CA, 1986**

Concentrated studies in networking, communications, data storage, memory hierarchies, interfaces, computer architecture, performance measurement, and error correction coding.

- **B.S. Computer Engineering, Lehigh University, Bethlehem, PA, 1981**

Emphasis on core engineering, computer programming, architecture, physics, and mathematics.

Experience:

- **GridPlan, Santa Clara, CA., 2003 - present**

Architect

Introduced the first open source capacity planning tool for Grid Computing that enabled both Enterprise, e-business and Scientific environments to accurately access the value of computational grids, cloud computing, large-scale Linux clusters, blade servers and distributed compute farms. Provided the crucial ability to assess cost-performance of interconnection strategies (such as Infini-Band, 10 Gigabit Ethernet, Myrinet), processors (such as XEON, Opteron), storage, switches and middleware. Established partnerships with Grid Global Forum (GGF), hardware vendors, independent software vendors and open source providers to provide best-of-breed planning technology to IT shops.

- **Center for Research in Storage Systems, University of California, Santa Cruz, CA, 2009 – 2017**

Executive Director and Project Scientist

Engaged in research and funding related activities. Worked with faculty to develop funding strategies and manage industrial sponsors. Participated in NSF and UC led events designed to attract research funding into the data storage space. Built relationships with industrial and academic contacts. Advised graduate and undergraduate students and reviewed their results pre-publication. Created a new area of research in Genomic Data Storage and incorporated into CRSS. Under NSF guidance, organized a group of similar centers in Data Analytics and Data Visualization to propose a new Engineering Research Center in Data Science for Health.

- **BookRenter, San Jose, CA, 2006 – 2008**

CTO

Led the team that created the first nationwide book rental service. Defined the architecture of a new web 2.0 platform for e-business that combines distributed computing with Ruby on Rails (RoR), MySQL, and web services of partners like Amazon, Barnes & Noble and UPS. Formed capitalization strategy, managed fund-raising activities and created partnerships to maximize equity leverage. Responsible for all technical aspects of www.bookrenter.com from hiring to operations.

- **Corosoft, Inc., Cupertino, CA, 2001 - 2003**

CTO, Founder

Developed a novel approach to managing enterprise e-business applications (databases, app servers, web servers, file services, network services). Introduced Corosoft virtualization software that aggregates resources (servers, networks, storage) behind application services. Built team, raised \$3.8M funding, delivered product to market. Established partnerships in enterprise management (BMC, HP), grid computing (Platform, IBM), network content management (F5) and software (Oracle, Microsoft). Extended strategy to include power management (ACPI) middleware, streaming, clustering file systems, volume management and flexible storage architectures.

- **Western Digital Corp., San Jose, CA., 1999 - 2001**

Vice President, Systems Architecture

Responsible for all aspects of technology in the formation of new business units. Reported to the Chief Technical Officer and VP of Business Development. Identified new technologies for Enterprise Storage Area Networking (SAN) and Audio/Video streaming storage networking systems, most notably switched fabrics. Drove strategic relationships with well-established software companies such as Microsoft and Veritas for existing technology. Identified and structured relationships with partners and performed due diligence on emerging key technology startups that led to

capital investment of \$2-5M. Created detailed business plans including capitalization, development and staffing requirements.

- **Quantum Corp., Milpitas, CA, 1993 - 1999**

Storage Architect, Director, Network Storage Architecture Group

Manager, Advanced Storage Applications Group

Led team that developed the first low-cost Network Attached Storage (NAS) disk and tape products. Coordinated company-wide technology direction for storage management, file systems, device drivers, BIOS, and APIs for FibreChannel (FC), Gigabit Ethernet (GbE), InfiniBand (IB), Redundant Arrays of Independent Disks, etc. Responsible for technical relationships with strategic partners, such as Microsoft, Legato, Veritas, Oracle. Supported business units with cross connects to Compatibility Lab, Design Engineering, Sales and Marketing. Participated in customer investigations of new storage applications and developed requirements for new storage markets. Managed architecture and performance labs to provide real data for product planning. Created and managed storage simulator team that laid groundwork for delivery of SCSI, IDE, ATA-33, to 133 interfaces, ultimately resulting in net savings of \$50M+. Participated in architecting, planning and specification of Self-Monitoring, Automatic Reporting Technology (S.M.A.R.T.) for intelligent storage devices.

- **Institute for Information Storage Technology, Santa Clara University, 1990 - 1993**

IIST Research Fellow and Instructor in Electrical and Computer Engineering (Adjunct Faculty)

Investigated performance of magnetic disk, optical disk, magnetic tape, and buffering in relation to computer system performance. Researched data storage interfaces and architectures and interacted with local data storage industry. Developed relationships with companies such as Quantum, Conner, Seagate, IBM, Iomega and Maxtor. Generated research proposals including budget and staffing requirements and followed proposals through federal government approval. Represented IIST as part of the \$24.5M NSIC Ultra-High Density Storage project. Responsible for teaching graduate and undergraduate courses.

- **I/O XEL Incorporated, Santa Clara, CA, 1986 - 1990**

Director of Engineering

Developed and delivered performance analysis tools for the data storage industry including The SCSI Benchmark® tester. Clients included Quantum, Priam, Maxtor, Iomega.

- **Scientific Micro Systems, Mountain View, CA, 1982 - 1986**

Design Engineer

Designed disk controller firmware for IEEE 796, LSI-11, and SCSI-based disk controllers with embedded microprocessors and microcontrollers. Participated in successful IPO.

- **National Semiconductor, Santa Clara, CA, 1981 - 1982**

System Engineer

Designed and delivered the hardware and firmware of a Winchester Disk Controller for IEEE 796 bus.

- **Digital Equipment Corporation, Tewksbury, MA, 1978 - 1979**

Software Engineer

Designed conformance tests for compilers and test packages for the VAX 11/780 VMS debugger.

Languages: Java, XML, HTML, UML, c, c++, 8086 assembler, 2900 bit slice, FORTRAN

Operating Systems: Windows, NT, XP, ME, Linux, Ultrix, AIX, MS-DOS, VMS, CPM

Interfaces: SCSI, IDE, ATA, FibreChannel, Gigabit Ethernet and TCP/IP, 10 GbE, InfiniBand, ISA, PCI

Patents:

U.S. Patent 9,358,259, "Recycling cannabinoid extractor"

U.S. Patent 9,155,767, "Essential element management" Issued October 13, 2015

U.S. Patent 8,980,941, "Controlled Cannabis decarboxylation" Issued March 17, 2015

U.S. Patent 8,343,553, "Essential element extractor." Issued January 01, 2013.

U.S. Patent 7,274,659, "Providing streaming media data." Issued September 25, 2007.

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U.S. Patent 6,965,563, "Resource reservation system in a computer network to support end-to-end quality-of-service constraints." Issued November 15, 2005.

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2 for transmission through a multi-dimensional switched fabric network." Issued
June 1, 2004.

3 U.S. Patent 6,697,914, "Switched node comprising a disk controller with integrated
4 multi-port switching circuitry." Issued February 24, 2004.

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stream data." Issued September 2, 2003.

6 U.S. Patent 6,603,625, "Spindle synchronizing in a multi-dimensional network."
7 Issued August 5, 2003.

8 U.S. Patent 6,470,420, "Method for designating one of a plurality of addressable
9 storage." Issued October 22, 2002.

10 U.S. Patent 6,012,839, "Method and apparatus to protect data within a disk drive
buffer," Issued January 11, 2000.

11 U.S. Patent 5,771,397, "SCSI Disconnect/Reconnect timing algorithm for optimal
12 performance." Issued June 23, 1998.

13 U.S. Patent 4,851,998, "Method to Analyze Performance of Computer Peripherals."
14 Issued July 25, 1989.

15 As of Jan 2017, the above patents were cited 326 times as prior art in patents granted by the
US Patent and Trademark Office.

16 **Peer Reviewed Publications:**

17 Preeti Gupta, Avani Wildani, Daniel Rosenthal, Ethan L. Miller, Ian Adams, Christina
18 Strong, Andy Hospodor, "An Economic Perspective of Disk vs. Flash Media in
19 Archival Storage," Proceedings of the 22th IEEE International Symposium on
Modeling, Analysis, and Simulation of Computer and Telecommunication Systems
(MASCOTS 2014), September 2014. [Archival Storage]

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21 Rekha Pitchumani, Andy Hospodor, Ahmed Amer, Yangwook Kang, Ethan L. Miller,
Darrell D. E. Long, "Emulating a Shingled Write Disk," Proceedings of the 20th
22 IEEE International Symposium on Modeling, Analysis, and Simulation of Computer
and Telecommunication Systems (MASCOTS 2012), August 2012. [Shingled Disk]

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24 Ziqian Wan, Alex Nelson, Tao Li, Darrell D. E. Long, Andy Hospodor, "Computer
Hard Drive Geolocation by HTTP Feature Extraction," Technical Report UCSC-
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Schwarz, "Redundancy Management for P2P Storage," CCGrid 2007 CCGrid 2007,
27 the 7th IEEE International Symposium on Cluster Computing and the Grid, Rio De
Jeniero, Brazil, May 2007.

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Awarded Best Paper.

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1 Andy Hospodor, "Storage Interfaces & Architectures" and "RAID Technology,"
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3 *IEEE Laser Electro-Optics conference*, Maui, HI, May, 1993

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6 Andy Hospodor, "Measuring and Modeling Storage Access Times", seminar for UC
Berkeley Computer Science Department, January 1992.

7 A. Hospodor, "Storage Interfaces and Architectures", an invited tutorial, presented
8 IEEE Systems Design and Networks Conference, Santa Clara, CA, June, 1990.

9 Andy Hospodor, "SCSI Throughput, How it Affects Performance", DiskTest
10 Conference, San Jose CA, July, 1989.

11 Andy Hospodor, "Survival SCSI", an invited tutorial, IEEE Systems Design and
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25 Publishing, vol. 20, no. 2, February, 1987.

26 **Professional Activities:**

- 27 • Member, American Association of Cancer Researchers

- Member, Society of Cannabis Clinicians
- Panelist, National Science Foundation review of Big Data Initiatives 2014, 2015, 2016
- Panelist, National Science Foundation review of the National Middleware Initiative (NMI) 2004
- Senior Member, IEEE and Computer Society
- Member, IEEE P1285 standards committee
- Member, Infiniband trade association
- Member ACM, Special Interest Group for Performance Evaluation (SIGMETRICS)
- Member, Grid Global Forum (GGF), Globus
- Invitee, the 2004 International School of Grid Computing, Vico Equense, Italy
- Past program chair of Magnetism Society, Santa Clara Valley chapter
- Research affiliate of University of California, Santa Cruz, System Storage Research Center
- Research associate and Lecturer of Santa Clara University, Computer Engineering Dept.

Expert Witness:

- **SBC v. InRange, 2004 – 2005**
Brooks, Kushman, Detroit, MI, Northern District of Texas, 3:03-cv-00418
- **Exabyte v. Certance, 2005**
Weil, Gotshall and Manges, Redwood Shores, CA, District of Colorado, 1:04-cv-02061
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- **HP v. SBC, 2005**
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- 1 • **Axalto v. Toshiba, 2006**
2 Osha – Liang, Santa Clara, CA, Eastern District of Texas, 5:06-cv-00059
- 3 • **Tandberg Data v. Hewlett-Packard, 2006-2008**
4 Bartlitt-Beck, Denver, CO, 01/20/2006, District of Colorado, 1:06-cv-00102
- 5 • **Mathworks v. Comsol, 2007-2008**
6 Nixon Peabody, Boston, MA, Eastern District of Texas, 6:06-cv-00334
- 7 • **Overland Storage v. IBM, 2011**
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- 10 • **Round Rock v. Dell, 2012**
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- 12 • **Overland Storage v. Quantum, 2013**
13 Durie Tangri, San Francisco, CA, Case: 3:12-cv-01599-JLS-BLM
- 14 • **Farstone v. Apple, 2014**
15 Morrison & Foerster, Los Angeles, CA, Case 1:14-cv-01244-LMB-IDD
- 16 • **AMD v. LG, 2015**
17 Fish & Richardson, Washington, DC, Case 8:13-cv-01537-ODW-JEM
- 18 • **CrossRoads v. Quantum, 2015**
19 Durie Tangri, San Francisco, CA; Haynes and Boone, Dallas TX, Case No. 14-CV-
20 00150-SS
- 21 • **MicroStrategy v. OpenRisk, 2015**
22 Gleason & Gleason, Boston, MA, Case 1:14-cv-01244-LMB-IDD
- 23 • **EMC v. Pure Storage, 2016**
24 Choate Hall, Boston, MA, Case 1:13-cv-12789-JGD
- 25 • **Allen v. County of Lake, 2017**
26 Porter Scott, Sacramento, CA, Case 3:14-cv-03934-THE
- 27
- 28

1 • **Sony v. Fujifilm, 2017**

2 Baker Botts, New York, NY, Investigation No. 337-TA-1036, International Trade
3 Commission
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EXHIBIT A TO APPENDIX 1

Begin Bates	End Bates
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BB_CTRL0001322	BB_CTRL0001322
BB_CTRL0001887	BB_CTRL0001887
BB_CTRL0001888	BB_CTRL0001888
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